GAS JOURNAL, AUG. 9, 1944

VOL. 244 96th YEAR No. 4238

EDITORIAL NOTES

FUEL ECONOMY

FOR two years now the Ministry of Fuel and Power has been campaigning in the cause of fuel economy. The period since July, 1942, has seen the formation of fuel efficiency committees in each of the 12 Civil Defence Regions, and the planning and carrying out of a systematic drive for fuel efficiency throughout the industries of the country under the direction of the Ministry's main committee, of which Dr. E. S. Grumell is Chairman. The central feature of the campaign has been factory inspection; and 700 engineers, both full-time and voluntary, have been enlisted and are carrying out inspections at factories at the rate of 1,500 a month. Up to December, 1943, nearly 12,000 first visits and 5,000 follow-up visits had been made to factories whose coal consumption aggregates nearly 40,000,000 tons a year; and in several of the Regions every coal consumer of any size had been visited once or oftener. The work is under the direction of the regional committees, who consider the reports and contribute their experience in the recommendations made. The engineers' estimates of the savings that would result from carrying out their recommendations appear to average about 10%—*i.e.*, 4,000,000 tons per annum—and this estimate does not represent the full extent of the fuel efficiency campaign, for it does not include the economies in gas, electricity, and fuel oil which have resulted from the co-operation of representatives of these industries with the regional committees. It has been demonstrated well enough that enormous savings can be made in the use of gas, electricity, and coal by purely administrative means with existing equipment. There have, for instance, been many cases of immediate savings of 33% or so in gas consumption in industrial work and in commercial and military use by the exercise of thought and care by administrative staff and general management. The fruitful activities of "gas chasers" in this direction have been referred to on several occasions in these columns.

A pamphlet just published by the Ministry of Fuel gives a general account of what has been achieved in the fuel efficiency campaign since its inception. The ground covered has been extraordinarily wide. Mention is made of the large number of technical bulletins which have been issued, distribution of which has already reached a figure of 800,000. Then there are the training schemes for managements, stokers, and factory personnel. To date lectures and demonstrations have been given to over 14,000, and the courses have been operated at 120 centres. A recent development has been specialized lectures on various aspects of power and heat utilization adapted to the needs of particular regions. The Gas Industry—in common with several other major coal-using industries—has its own fuel efficiency committees whose work has been co-ordinated with that of the Ministry, and the pamphlet pays tribute to the help which has been given by the larger undertakings to the smaller units. In comparison with what may be termed general industry the scope for improvement in fuel economy in the Gas Industry is not so great; yet despite the Industry's grave difficulties in maintaining an increased output in the face of shortage of labour and opportunity to maintain plant the economy aim is a matter of 250,000 tons of coal a year.

Behind the facts and figures set out in the pamphlet under review lies a story of great expansion of fuel efficiency activities, without which there is no doubt the country's industries would have found it difficult to maintain war production with the fuel supplies available.

PHYSICS AND MATHEMATICS

"AS the results of the present research work are applied, the technique of gas-making will gradually change." This is quoted from the recent I.G.E. Paper by Mr. G. C. Pearson, in which he discussed the training and qualities of the future gas engineer, and in which he expressed the view that the future gas engineer will emerge as a specialist. A fresh set of problems will develop. We must become accustomed to processes involving higher pressures than those in use at the present time. Steam pressures will probably be higher; the design of ancillary plant such as exhausters and boosters may change. There may be transformations in the design of apparatus. Undoubtedly in many spheres men trained primarily as physicists will be called upon. We have written generally about physicists and gas-making and gas utilization before; we should like at the moment to call attention—with the big flea and the small flea idea in mind—to an aspect of the training, not of the gas engineer, but rather of the physicist who will be or should be employed in the service of the Industry more and more in the future. We do so in the light of a report just published by the Institute of Physics, which report is concerned with the teaching of mathematics to physicists. The report is a joint one by the Institute with the Mathematical Association. We realize that the recommendations contained in it have been made specifically to the teaching of mathematics to physicists, as its title implies, but we think they may be of equal interest to those concerned with training in other sciences and in engineering, and that the logical opinions expressed will be of interest to many more than those directly interested in teaching.

As the report points out, some knowledge of mathematics is essential to every experimental physicist. It provides the logic by which he can best develop his ideas, and the language in which his results can most conveniently be expressed. At a conference held under the aegis of the Institute of Physics some time ago, the view was put forward strongly that the type of training in mathematics received by students of physics failed in some respects to meet the requirements of the times. A Committee consisting of representatives of the Institute and the Mathematical Association was set up to report on changes which appeared desirable, and the present document is the result. The report can be obtained gratis from the Institute of Physics at its temporary offices at Reading University, and we do not propose to discuss it in any detail. The overriding opinion of the Committee seems to be that the mathematical needs of the average student of physics cannot be fully satisfied by any selection from among the courses normally provided for students of mathematics, and it is recommended that there should be instituted a special course or courses in mathematics for students in physics. Such courses, it is suggested, would be found equally suitable for students of other sciences, either pure or applied.

Arguments, methods, and constructions are used in industry, the Gas Industry not excepted, which are essentially similar to mathematical theorems and processes often of an advanced character; and we very much like the quotation in the report from Sir J. J. Thomson's *Recollections and Reflections*. It runs: "One of my pupils came at the beginning of his third year with a very bad record. He was said to be idle, to take no interest in his work, and to have very little chance of getting through the Tripos. At first I agreed with this estimate, but we plodded on until we came to the subject of collisions between elastic spheres.

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I knew he was fond of billiards, and so I pointed out to him that the rules he used for playing certain shots at billiards followed at once from his mathematics. The result was marvellous. He had never before conceived that there was anything in mathematics that could interest any reasonable being. He now respected it . . . and he learnt enough in the few months that were left before the Tripos to take quite a respectable place among the Senior Optimes. If it had not been for the billiards he would have been ploughed." This suggests that mathematics may often be more easily learnt and more confidently used if presented as the quantitative and generalized form of logical processes familiar in the world of physics and, in fact, often considered as "common sense." A mathematical training of this kind, losing in rigour but gaining in objectivity, should be within the competence of most students.

Of course, a student whose mathematical ceiling is really unduly low would probably be well advised to transfer his interest from physics to some other branch of science.

Potterton's and Plastics

The announcement that Messrs. De La Rue Plastics, Ltd., have acquired financial control of the very old-established firm of Messrs. Thomas Potterton (Heating Engineers), Ltd., will cause widespread interest in the Gas Industry, which has long regarded Potterton's highly specialized installations as well as their high-class "bread-and-butter" appliances as very valuable media for giving service to the gas consumer. It is scarcely necessary for us to pass on to the Industry the assurances which Messrs. A. B. and T. F. C. Potterton have given us that the amalgamation indicates no uprooting of the tradition which the family has built up by the scientific application of hard work, because clearly the name De La Rue would not stand where it does if it had no better ideas than that. In fact, we can congratulate Potterton's upon their choice of the means towards future expansion just as heartily as we can De La Rue on their prescience in making their entry into the Gas Industry under the sponsorship of Potterton's. And so Messrs. Albert and Fred, as they are affectionately known both within the firm and in much wider circles, remain joint Managing Directors, and Mr. Ernest G. Brooks remains General Manager, and happily they and their powerful new allies foresee new and increased scope for the products of the Gas Industry, and intend being fully prepared to meet all demands. This, to our mind, is the most important immediate aspect of the matter, that a firm of world-wide rather than nation-wide resources is prepared at this stage to make a first investment in our Industry. Yet we must not lose sight of the plastics aspect, even if we are unable at the moment to see clearly its exact bearing. It is generally understood that we are about to enter the plastics age, and plastics cover a vaster field than the ash-trays and bell-pushes which they primarily suggest to the man in the street. When industry turns from war to peace we shall no doubt have revealed to us surprising developments in the application of this comparatively new group of materials to our everyday life. Needless to say we who live in and by the Gas Industry will be particularly interested in furthering the application of its immense potentialities to the consumer service which is our aim.

Personal

Mr. T. CAMPBELL FINLAYSON, M.Sc., has been appointed Technical Director of the Woodall-Duckham Vertical Retort & Oven Construction Company (1920), Ltd., in succession to Dr. E. W. Smith, C.B.E. Mr. Finlayson has been associated with the research and development work of the Company since 1921, and was Deputy Technical Director from 1932 until he joined the Board in 1941.

* * *

Mr. A. C. BUREAU, B.Sc., and Mr. J. W. GIBSON have recently joined the staff of Messrs. Henry Balfour & Co., Ltd. A graduate of Leeds University in Gas Engineering, Mr. Bureau has already had technical experience on the contracting side of the Gas Industry, while Mr. Gibson is well known in connexion with the "Simplex" water gas plant, for the design of which he was responsible.

* * *

Major F. BEDFORD, of the Straits Settlements Volunteer Force, Gas Engineer to the Municipality of Singapore, was taken prisoner on the fall of the Malayan Peninsula. His friends will be glad to know that Mrs. Bedford had a radio message from her husband in March last. Their only son, FRED ALEXIS BEDFORD, who was serving with the Royal Tank Corps in Normandy, was killed on July 2.

* * *

Mr. J. W. PALLISTER, Middlesbrough's Gas Engineer and Manager, has been elected a Member of the Institution of Civil Engineers, being transferred from the class of Associate Member.

Squadron-Leader H. CARTWRIGHT RANDALL, R.A.F., has been awarded the Distinguished Flying Cross. He is the son of Mr. H. J. Randall, Managing Director of the Yorktown (Camberley) and District Gas and Electricity Company and Chairman of the Horley and District Gas Company.

Obituary

T. P. Ridley

It is with regret that we have to announce the death of Mr. THOMAS PERCY RIDLEY, late Director and General Manager of the Newcastle-upon-Tyne and Gateshead Gas Company. He died at Alnmouth on Aug. 2.

Entering the Gas Industry as a Junior Clerk with the Newcastle Gas Company in 1889, Mr. Ridley eventually became Secretary in 1918, and finally rose to his present position of General Manager and Secretary in 1938. On the occasion of that appointment the late John E. Cowen, then Chairman of the Company, paid high tribute to Mr. Ridley when he said that he was "regarded as one of the ablest and most go-ahead administrators in the Gas Industry. . . . It is no exaggeration to say that had Mr. Ridley desired he could in all probability have had a more lucrative and perhaps more spectacular position elsewhere, but his loyalty to the Company he joined as a boy kept him in Newcastle, to the great advantage of the Company."

On the completion of 50 years' service with the Company a presentation was made to Mr. Ridley by the Directors, and on that occasion particular reference was made to his active share in the introduction of various schemes for the benefit of the Company's servants. He retired in 1940 after 51 years with the Company, when he was appointed to a seat on the Board.

Outside the Newcastle Company Mr. Ridley rendered outstanding service to the Industry as a member of the Executive Committees of the National Gas Council, British Commercial Gas Association, Sulphate of Ammonia Federation, British Pitch Association, and British Road Tar Association, and as a member of the Durham District Committee of Investigation under the Coal Mines Act, 1930. He was a member of the National Gas Council Committee on Gas Charges whose report was issued in 1928, and a member of the Board of Trade Committee on Gas Legislation upon whose recommendations the provisions of the Gas Undertakings Act, 1934, were based. He submitted Papers on behalf of the Gas Industry to the World Power Conference in London, 1928, and Berlin, 1930, and also to the American Gas Association on the occasion of the visit to America of the delegation from The Institution of Gas Engineers in 1933. He was President of the North of England Gas Managers' Association in 1937, and was awarded the Institution Silver Medal for a Paper on Gas Tariffs which was read before the Association. He also gave evidence before Select Committees of Parliament.

Mr. Ridley was a Director of the Shotley Bridge and Consett District Gas Company, Newbiggin-by-the-Sea Gas Company, Ltd., Amble and Warkworth Gas Company, and the National Benzole Company, Ltd.

Few men won for themselves greater respect—and more friends—in the Gas Industry.

Since his retirement from the General Managership of the Newcastle Gas Company 3½ years ago Mr. Ridley's health remained a source of anxiety to his many friends, but he refused to abandon his active participation in the affairs of the Industry to which his whole working life had been devoted, and only during the last few weeks of his life was he unable to attend the meetings of the several boards of which he was a member.

The industry is the poorer by the loss of a wise and experienced counsellor to whom it owes much, and those who shared in his work by the loss of a good friend who will long be remembered with respect and affection.

Mr. Ridley leaves a widow and two children, a son, who is on active service in the Navy, and a married daughter.

Institution of Gas Engineers

The many friends of Mr. JOHN TERRACE, Honorary Secretary of the Institution, will be very sorry to learn that he has had his home destroyed by enemy action. Fortunately Mr. Terrace and his daughter, who were in their shelter at the time, escaped unhurt.

An Amalgamation

De La Rue Plastics, Ltd., have acquired the whole of the issued share capital of Thomas Potterton (Heating Engineers), Ltd. Mr. Herbert Bridge, of Thomas De La Rue & Company, has joined the Board of Messrs. Potterton's, Ltd. Mr. A. B. Potterton and Mr. T. F. C. Potterton will remain on the Board of the Company as joint Managing Directors, and Mr. Ernest G. Brooks has been confirmed in his appointment as General Manager.

Diary

Sept. 8.—North British Association of Gas Managers: Annual Meeting, Edinburgh.

§§

Wet Purification of Vertical Retort Gas*

By J. A. SPEERS, Preston Gas Company

IN considering ammonia recovery and the wet purification of gas produced in continuous vertical retorts, many aspects present themselves which are inseparable from carbonizing plant conditions. In this Paper it is proposed first to discuss conditions in general, and secondly to describe the methods employed at Preston to recover the ammonia from the gas.

General Considerations of Ammonia Washing

When steaming of the coal charge is practised, which is universally the case when coal is carbonized in continuous vertical retorts, the amount of liquor produced per ton of coal will be controlled by the efficiency of the steaming reaction, and thus retort house control has a primary influence upon washing conditions.

The factors influencing the volume of water vapour in the gas leaving the retort house are as follows:

1. Free water in the coal charged to the retorts.
2. Inherent moisture in the coal.
3. Amount of undecomposed steam leaving the retorts.
4. Internal reactions in the decomposition of the coal causing combination of hydrogen and oxygen.
5. Combination of hydrogen in the gas with oxygen drawn in with air at the top of the retort.
6. Water vapour present in producer gas which may leak into the retort.

The first four items are the most important and account for the bulk of the water vapour condensed from the gas, but any or all may influence the total quantity produced. Considering each item in turn:

(1) *Free Water in Coal.*

In dry weather this becomes negligible when screened coal is used, but during prolonged rainy periods the coal can hold considerable quantities of rainwater. When a wagon of coal has been exposed to heavy rain for three or four days it may be found to hold as much as 2% of free water on the weight of the coal. This is equal to 44.8 lb. or 4.48 gallons of water per ton. It will thus be seen that feeding wet coal to the retorts has a very appreciable effect on the quantity of liquor produced, and it may be noted that small coals present a greater surface area to the weather than large ones and thus are more greatly affected by rain.

(2) *Inherent Moisture in Coal.*

All coals contain a certain amount of fixed moisture. In horizontal retort practice much of this is vaporized, and then decomposed into water gas as it travels through the hot coke near the wall of the retort.

In continuous vertical retorts, however, this does not apply, as the whole of this moisture is driven off in the upper part of the retort before the charge approaches the temperature required for the water gas reaction to take place.

The quantity of inherent moisture varies greatly; a good quality Yorkshire coal may contain 1.5%, while other seams are as high as 6% and upwards.

Expressed in terms of liquor, 2.24 gallons of liquor per ton are produced for every 1% present in the coal, so that a coal containing, say, 3.5% moisture will produce 7.84 gallons of liquor from this source alone.

(3) *Undecomposed Steam.*

A greater quantity of undecomposed steam than often is realized passes up a retort working with moderately high steaming. From the carbonizing point of view such a state of affairs is not wholly a bad fault, as it fulfils a useful function in cooling the coke entering the extractor chamber and transmitting the heat to the upper part of the charge, where, unless slacks are being charged to the retorts, it gives up the greater part of its heat in raising the temperature of the coal charge.

It has been found that the gases leaving the retorts under these conditions are frequently as low as 120°C., while the temperature of the charge about 2 ft. below the surface of the coal in the retort may be as high as 450°C. This steam also fulfils the function of creating a slight pressure in the retort below the point of high gas evolution, and thus reduces the possibility of producer gas being drawn in through cracks in the brickwork of the retorts.

The weight of steam undecomposed increases as the percentage admitted increases. Barash and Tomlinson [1] found that at 7% steaming 100% of the steam was decomposed; while at 40% steaming only 53% was decomposed. Experience shows, however, that generalization is dangerous, and that the results indicated above are only obtained under good conditions. Temperature of the lower part of the retort, reactivity to steam of the coke produced, and the completeness of the carbonizing reactions all influence the rate of decomposition.

Perhaps the most important of these items is the type of coke produced, as it has been found that with a reactive coke produced from Yorkshire washed nuts, as high a steam decomposition efficiency was obtained in retorts with moderately low bottom temperatures as in those with higher bottom temperatures, the average temperature over the full length of the retorts being the same in each case.

When the same test was applied to a mixture containing 20% unscreened Durham coal a much less reactive coke was produced, and while a reasonable amount of decomposition occurred in the latter case, the efficiency of the former was extremely low. Further, this last mixture produced little, if any, heat of reaction on carbonization, and in spite of the fact that the extractor speed was reduced to the extent of lowering the throughput by 6%, carbonization was not complete when the coke was withdrawn. Under these conditions efficient steam decomposition could not possibly occur.

It is therefore of interest to compare the different results of steam decomposition efficiencies obtained under different conditions, and Table I demonstrates this, while in Table II is shown the effect these conditions have on the quantity of liquor produced.

(4) *Internal Reactions.*

It is known that chemical reactions take place inside the structure of the coal when heated, which produce water in addition to that already present as inherent moisture.

The Fuel Research Board, in investigating the primary decomposition of coal, [2] shows that water is evolved in considerable quantities. In other Technical Papers [3] it is shown that liquor in excess of that from inherent moisture is formed on carbonization, and Table III shows this information extracted and reduced to gallons of liquor per ton of coal.

From these figures it is seen that from 8 to 16 gallons per ton may be derived from this source.

(5) *Combustion of Hydrogen.*

Clucas [4] records that E. V. Evans found that when oxygen is admitted to the ascension pipe of a horizontal retort, combination takes place with the hydrogen in the gas to form water. It is probable that a similar reaction can occur with gas from a vertical retort when air infilters through the top casting, and this presents a possible explanation for the frequent presence of nitrogen in the gas without a corresponding quantity of oxygen (after allowing for absorption in the purifier boxes), as on analysis the water vapour (containing the oxygen) is condensed.

The amount of nitrogen in gas (excluding nitrogen combined as ammonia) evolved from the coal substance never exceeds 1% [5]. All further nitrogen must come from the atmosphere either entrained with the steam, leakage of producer gas, or infiltration of air. In all three cases it will be accompanied by the corresponding amount of oxygen, either free or chemically combined.

In several cases of retorts becoming hot on top, signs of combustion have been observed with no noticeable increase in the CO_2 content of the gas. It has also been observed that an unaccountably high nitrogen content of the gas has occurred under these conditions. Typical results of this nature show that 0.5 gallon of water per ton can be formed from this source alone.

(6) *Water Vapour in Producer Gas.*

Normally no great leakage of producer gas into the retorts should occur, and it is always extremely difficult to determine if it is present to any appreciable extent in coal gas by analytical methods; hence it generally remains an unknown quantity.

It should be noted that with producer gas as is normally used to heat vertical retorts, about 7% of the products of combustion consists of water vapour, and if a leakage of these products into the retorts occurred to the extent of 2% on the volume of gas made, it would add some 24 cu.ft. of water vapour per ton of coal to the gas, increasing the liquor by a further 0.11 gallons per ton.

Summing up the sources from which liquor can be derived, the following figures represent the maximum of each item likely to be met with and the quantity that might be expected with steaming at 7½% and 21% respectively. It must be borne in mind, however, that it is extremely improbable that all the items will ever reach a maximum at one and the same time.

Item.	Maximum Gall./Ton.	7½% Steaming Gall./Ton.	21% Steaming Gall./Ton.
(1) Free water	4.5	1.5	1.5
(2) Inherent moisture	10.0	5.0	5.0
(3) Undecomposed steam	30.0	3.0	20.0
(4) Internal reactions	16.0	10.0	10.0
(5) Combustion of H_2	0.5	0.4	0.3
(6) From producer gas	0.1	*Nil*	*Nil*
Total	61.1	19.9	36.8

The next matter for consideration is the amount of ammonia formed when carbonizing in vertical retorts. It is believed that the nitrogen content of the coal substance is entirely organically combined and not associated with the mineral matter of the coal. When decomposition takes place on carbonization, this nitrogen is in a chemically active state, and when steaming is practised, conditions are favourable for chemical combination of the hydrogen with the nitrogen to form ammonia.

* From a Paper to the Manchester and District Junior Gas Association.

The weight actually produced varies between 5.5 and 7.5 lb. of ammonia (NH_3) per ton of coal carbonized, which is equivalent to between 214 and 292 grains NH_3 per 100 cu.ft. of gas when 18,000 cu.ft. per ton are being obtained.

Strength of Liquor.

From the foregoing it is obvious that, if no additional water were added, the maximum concentration of ammonia in liquor is fixed by the factors enumerated and, taking the mean figure for water produced as 28 gallons per ton and 6.5 lb. of ammonia per ton, the maximum possible total strength will be 2.32%. It only needs, however, a slight increase in one of the other factors discussed to lower its strength considerably, and a liquor make of, say, 35 gallons per ton, which is quite usual when steaming down to 450 B.Th.U. per cu.ft., brings the maximum strength to 1.85%.

It is immediately apparent that highly efficient washing plant can do little in itself to improve this figure, although an efficient plant will require little, if any, additional water, and rigorous exclusion from the well of all drainage will prevent the strength being lowered further.

The methods of liquor circulation available are dependent upon whether or not strength of ammonia concentration is a prime factor. Those undertakings which are so located as to be easily able to dispose of their effluent may welcome weak liquor, and improve their washing efficiency by utilizing a copious supply of water to the plant. Others are able to incorporate a double effluent system, whereby a proportion of the weak liquor from retort house circulation is bled off and disposed of down the drain. This enables the remainder to be worked up to a higher strength.

If, however, there is no such means of disposal available, the necessity for keeping the volume of liquor produced to a minimum is imperative, and as the undecomposed steam is the only large item over which it is possible to exercise any control, it becomes apparent that this matter is the one that commands the greatest attention. Ways and means of effecting this are, however, outside the scope of the present Paper.

In cases where part of the liquor can be disposed of, an opportunity is afforded to benefit from the high efficiency of the modern type of washing plant to reduce the ammonia in the gas to the desired amount, and obtain a strong effluent liquor which is admirably suitable for concentration or for sulphate manufacture.

Little, if any, water is needed, provided an efficient liquor cooling system is in operation, capable of handling up to 10 gallons per ton of coal, carbonized so that the temperature never exceeds 60°F., and an efficient system of tar separation so that a guaranteed supply of clean, cool liquor can always be maintained. This liquor can be bled from the retort house circulating system, provided provision is made for feeding back the effluent from the condensers into the system, or it may be formed of the early condensate from the foul main or condensers so long as the gas temperature has not fallen low enough to permit the absorption of much free ammonia at the point from which it is taken. The quantity of the latter will be somewhat limited, so that the former is preferable in order to afford ample tar separation.

Freedom from Tar Essential.

Freedom from tar is an essential if efficient working of the washing plant is to be obtained. Small traces of tar build up over a period and clog the scrubbing surfaces of the final washer, and only a film is required in the liquor to create a surface tension low enough to reduce the frothing, which is such a desirable feature, to negligible proportions.

It is therefore highly desirable that tar fog should be removed from the gas before it enters the washing plant. An electrostatic detarrer is the ideal solution to this problem, and its incorporation in the plant should be regarded as a necessity rather than a luxury. In the absence of such a detarrer, tar fog can be lowered by Livesey washers fed from a separate liquor stream, but in cases where part of the weak liquor is bled away to enable a high concentration of crude liquor to be obtained, it must be realized that this may wash out a considerable amount of the ammonia from the gas and interfere with the liquor strength of the effluent from the final washer.

Washer Efficiency.

Theoretically, a perfectly efficient washer would be one in which there is sufficient wetted surface in each chamber for every molecule of the gas to make contact with the liquid, and it would have the following features:

(*a*) An infinite number of effects.
(*b*) A perfect counter-current flow of gas and liquor.
(*c*) A low temperature of gas and liquor.
(*d*) Sufficient water flowing into the washer to give an ammonia strength in the effluent liquor in equilibrium at that temperature with the ammonia content of the gas entering the washer.

In practice these conditions cannot be obtained, but the following points tend in the direction of efficiency:

(*a*) A sufficient number of effects to enable a steady ammonia gas $\rightleftharpoons$ liquor gradient to be obtained.
(*b*) Efficient means of gas and liquor cooling.
(*c*) A high area of wetted surface in each chamber in relation to the gas flow and an efficient means of distributing the washing liquor in each chamber.
(*d*) A sufficient quantity of clean weak liquor and cold water available for washing the last stages, if required.

Gas and Liquor Equilibria.

Before discussing gas and liquor rates and the effect of temperature on the resultant efficiency, it is desirable to have some knowledge of the theoretical limits and quantities to reach a state of equilibrium under the various conditions. With this in view, a number of tables have been worked out from information given by several authorities (4) and are appended hereto. The figures shown are for complete theoretical efficiency, and due allowance must be made for the fact that such a state can never be achieved in practice. On the other hand, with the CO_2 content of vertical retort gas frequently above 4%, some allowance may be made for the increase in ammonia absorptive capacity due to the quantity of acid gases present.

Table IV shows the ammonia content of gas containing 3.5% CO_2 in grains per 100 cu.ft. in contact with liquor, with various contents of free ammonia over a range of temperatures. It will be seen from this table that it is impossible to concentrate liquor beyond a certain strength by gas with a definite ammonia content and temperature. Thus gas containing 100 grains of NH_3 per 100 cu.ft. entering a washer with gas and liquor at 60°F. can never concentrate the liquor above 4.76% free ammonia. Similarly, liquor containing 0.43% free ammonia at a temperature of 70° F. can never lower the ammonia in the gas below 10 grains per 100 cu.ft., whatever quantity is used or however great the efficiency of the washer.

Table V sets out the liquor strength obtainable at the liquor outlet of the washer at different rates of flow and varying ammonia contents of the gas, when the ammonia is being reduced to 5 grains per 100 cu.ft. at the gas outlet to the washer. As, however, this strength is also controlled by the temperature, as shown in Table I, a number of critical lines are shown for various temperatures above which the strength cannot be increased.

Table VI is similar to Table V, but is for liquor entering the washer with a free ammonia content of 0.35%. In this case it must be borne in mind that this liquor can never wash the ammonia down to 5 grains per 100 cu.ft. if the temperature exceeds 62°F.

Table VII sets out the equilibrium temperatures between ammonia in gas and in liquor for varying values of each concentration, and Table VIII is an extension of Table IV for liquors very low in free ammonia for temperatures up to 120°F.

Applications.

If high ammonia content effluent liquor is the aim to be achieved, and a satisfactory outlet has been made for surplus weak liquor, then a single washer of high efficiency can best be left to handle all the washing process. A two-stage washer would have the additional advantage of allowing half to be shut down while repairs were being effected.

From experience at the Preston works it has been found that the ammonia content of the gas entering the washing plant depends upon the temperature to which the condensers have reduced it, the condensate being sufficient to bring down as liquor a very considerable proportion of the total original ammonia. This quantity will vary with the amount of water vapour per ton of coal carbonized being sent out of the retort house, with the type of condensing plant in use, and with the rate of cooling due to weather conditions, etc. From a considerable number of tests it has been found that on the Preston plant the relation between the ammonia content of gas and temperature does not vary far from a straight line, and on this particular plant can be roughly evaluated by the empirical formula, where the ammonia content of the gas in grains per 100 cu.ft. is given by 2T—45, T being the temperature of the gas in degrees Fahrenheit.

Consider the case where the gas is cooled to 70°F. and is required to be washed by liquor containing 0.35% NH_3; then the ammonia in the gas entering the washing plant is about 90 grains per 100 cu.ft.

From Table VI a flow of liquor of 45 gallons per 100,000 cu.ft. of gas would be below the safety line for 70°F., and give a liquor concentration of 3.2% free NH_3.

Assume the liquor to enter the plant at 60°F., from Table IV the ammonia in the gas at the outlet would be 4 grains per 100 cu.ft.

In practice a safety margin on these figures would be required, and the most desirable way of attaining this is always by the lowering of temperature.

Now if the condensers were to reduce the temperature to 60°F., the ammonia content of the gas would fall to 75 grains per 100 cu.ft., and from Table V the liquor rate could be reduced to 30 gallons per 100,000 cu.ft., but the strength of the effluent liquor would only be increased to 3.7% free ammonia, as the concentration would be lowered by the condensers.

Finally, unless there is a plentiful supply of cool weak liquor, below 0.30% free ammonia at 60°F. or 0.36% at 55°F., it will be necessary to add water to the last bay to reduce the ammonia in the outlet gas to 4 grains per 100 cu.ft., as the strength of liquor in the last (gas outlet) chamber will always be above that of the liquor entering, and it is the strength of this liquor that in practice determines the final ammonia content of the gas.

The more efficient the type of washer in operation, the less will be the allowance needed for this factor.

System of Washing at Preston

The whole of the gas at the Preston gas-works is made in continuous vertical retorts working with about 20% steaming. This gives an average quantity of liquor at the retort house of 35 gallons per ton,

and the total ammonia recovered works out to give a maximum possible liquor concentration of 1.91% ammonia.

The gas passes from the retort house to ample atmospheric condensers, where the temperature drop can be adjusted by increasing or reducing the number of tubes in operation. Condensers of this type are subject to severe variations in heat loss with change of weather conditions, but the control mentioned is ample to keep the gas temperature at the exhauster between 90° and 100°F. From the exhauster the gas passes to two water tube condensers in parallel, with gasholder water circulated through them by a pump, where it is cooled to between 55° and 65°F.

A W.W.-D. detarrer has been installed immediately after the final condensers which removes all the tar fog from the gas before entering the washing plant, thus ensuring maximum efficiency of contact between the liquor and the gas.

The washing plant itself consists of two parallel sets of two Livesey washers, the outlets being connected into a common main. The final washing is done in a static washer recently erected by the Whessoe Foundry and Engineering Company, Ltd., of Darlington, with an old type rotary washer retained as a standby.

Liquor Supply.

The whole of the liquor made at the works at Lostock Hall is collected in an underground well, whence it is removed by road tanks to the works of a local firm of ammonia distillers.

It is therefore of the utmost importance that the strength should be kept as near the theoretical maximum as possible, by the rigorous exclusion of all drainage and other foreign liquid from the well, and to avoid the use of water in the washing process if at all possible. Consequently, the system adopted for the removal of ammonia from the gas has to be operated with a view to this.

Liquor and light tar is circulated through the hydraulic mains by circulating pumps feeding sprays in the hydraulic main offtakes, and a branch from this pipe also feeds a spray to the retort house governor to prevent the deposition of pitch. The liquor in the circulating system is maintained by pumping up the liquor and light tar obtained from the condensate from the foul main and condensers.

It may here be mentioned that the effluent from the electrostatic detarrer was found to contain a high percentage of water emulsified with the tar which seriously affected the water content of the tar in the tar well. A system has now been installed whereby this effluent is collected in a tank and thence circulated through the hydraulic mains, and this has been found to be an effective cure for the emulsification.

The effluent from the hot end of the condensers and from the foul main flows into a separating tank, and from the top of this tank is bled off the liquor for the final washer. This liquor passes to a liquor tower with an annular tube which acts both as a cooler and a final tar separator. From there it passes through a rack cooler and finally to the washer through a 1½ in. pipe through the centre of a 4 in. cast iron pipe, along which cold water flowing countercurrent to the liquor runs up to the retort house for coke quenching.

It is found that this system will cool 90 gallons of liquor per hour down to 60°F. in the summer months, so that an adequate supply is always available.

Provision is also made for a supply of liquor to the Livesey washers by bleeding off liquor from the overflow from the retort house circulating system into a separate tower, whence it is air cooled on its passage to the washing plant, and it is found that under ordinary conditions 50 gallons per hour can be cooled to 70°F. or smaller quantities to a lower temperature.

An alternative supply of cold stronger liquor from the well is also available, should this temperature ever rise. This liquor contains about 1.4% free ammonia and reaches about 60°F. in summer. Therefore its ammonia equilibrium is sufficient to reduce the ammonia in the gas down to 20 grains per 100 cu.ft., while the weaker liquor containing 0.35% free ammonia could theoretically reduce it to 8 grains per 100 cu.ft. at 70°F. or 16 grains at 80°F., so the need for using the strong liquor is rare.

The New Static Washer.

The washer is designed for a throughput of 5 million cu.ft. of gas per day. It consists of one unit of six compartments, 13 ft. 6 in. long by 9 ft. wide by 12 ft. high. Each of the six compartments is packed with wooden grids over which the liquor from the bottom of the compartment is continuously recirculated. These wooden grids are arranged in alternate layers running at right angles, providing a surface with a high degree of subdivision and uniformity, ensuring good liquor distribution throughout the filling.

The gas enters at the top of the first compartment and travels alternately downwards and upwards through each compartment, finally leaving the scrubber from the top of the sixth compartment. Between the second and third compartments and the fourth and fifth compartments the gas travels through the spray chamber, so in order to prevent spray being carried over from one compartment to the next a vertical wall of Raschig type rings is provided at each of these points. There is also a wall of rings at the outlet of the sixth chamber to prevent spray being carried into the gas outlet pipe.

The liquor is circulated through the compartments by a set of six centrifugal pumps driven by means of a Sisson steam engine geared to the pumps by Fabroil pinions.

This means of circulation ensures that no leakage of liquor can possibly occur between the pumps, which is an all-important factor in maintaining efficiency, and it enables repairs to be effected on an individual unit without shutting down the entire washer.

The liquor is distributed over the top of the grid filling by means of 4 sprays per compartment which are provided with a special "quick opening" fitting in the casing, so that the sprays can be quickly removed for examination and cleaning.

Particular care has been taken in the design to ensure uniform distribution of spray over the cross section of the scrubber filling, and special means have been adopted to prevent loss of efficiency due to the carrying over of any liquor to the next compartment with the gas stream. Provision is made for both liquor and water admission into the compartment at the gas outlet, and there is a further tun-dish to allow liquor to be admitted at any intermediate point in the washer, should it be required. The head of water is kept constant by means of an overhead tank fed through a ball tap, which ensures a constant supply. The head of liquor is similarly kept constant by means of the liquor-tar separator tower already described, where the liquor level is maintained by a weir valve overflow.

Operating Results.

For the purpose of obtaining information as to the capacity of the washer, the Livesey washers were by-passed, the whole of the washing being performed by the static washer, while handling a peak load.

When the washer was put into operation, liquor was admitted to the gas outlet bay having a concentration of approximately 0.35 gramme NH_3 per 100 c.c. As the temperature was below 50°F. it was apparent that with a sufficient quantity of this liquor the concentration in the sixth compartment (gas outlet) would be low enough to give an ammonia content in the outlet gas of 5 grains per 100 cu.ft.

A low rate of 16½ gallons per hour was tried at first, while the temperatures were low, due to weather conditions, and the ammonia in the gas was reduced to 6 grains per 100 cu.ft. This produced effluent liquor of 25 oz. strength (5.44 grammes per 100 c.c.), which was approaching equilibrium strength for the ammonia content of the gas. As, however, strong effluent liquor was not the object in view, the liquor rate was considerably increased to ensure that the ammonia passing forward to the purifiers was in the region of 5 grains per 100 cu.ft. when the temperature rose, due to milder weather conditions.

Some typical working results are shown in the table on this page.

The results are ample testimony to the efficiency of ammonia washing with a modern type of washer. With steamed vertical retorts it is not easy to obtain both low temperature and high ammonia content of the gas at the inlet to the washer. Therefore, with efficient washing it is not possible to work the effluent liquor strength up to the same concentration as it could be in the case of horizontal retorts. Nevertheless, given a reasonably low gas temperature, 25 oz. liquor can be obtained by giving the plant regular attention, and if, as is the case when weak liquor is the washing medium, there is a fixed ammonia content in the effluent of some 0.7 gramme NH_3 per 100 c.c., a total strength of 6.14% ammonia (28 oz.) has been obtained. For higher temperatures 20 to 23 oz. effluent strength is usual.

From the results enumerated above it becomes clear that the prime factor in control is the regulation of liquor rate, and this is principally influenced by the gas rate and gas inlet temperature.

Test number.	Gas rate Thous./ hour.	Gas temp. °F. Inlet.	Gas temp. °F. Outlet.	Liquor Gall. per hour.	Liquor Inlet temp. °F.	NH_3 in Gas Gr. per 100 cu.ft. Inlet.	NH_3 in Gas Gr. per 100 cu.ft. Outlet.	Free NH_3 in Liquor %. Bay 1.	Bay 2.	Bay 3.	Bay 4.	Bay 5.	Bay 6.	Inlet.
1	188	47	43	16½	45	47.8	6.0	5.44	4.71	3.42	3.09	2.33	1.46	0.42
2	178	67	51	72	48	82.0	5.9	2.92	2.14	1.50	1.02	0.65	0.42	0.30
3	204	58	52	72	46	70.1	7.2	3.82	3.20	2.68	2.21	2.04	1.00	0.31
4	172	53	48	72	44	67.2	5.0	4.39	3.48	2.41	1.77	1.20	0.74	0.38
5	178	61	59	72	45	78.5	7.9	4.05	3.33	2.69	1.97	1.35	0.83	0.38

It is also shown that with an efficiently designed wet purification system it is possible to eliminate the use of water entirely, while keeping the gas entering the purifiers to an ammonia content of 5 grains per 100 cu.ft.

References

(1) *Proc. Third International Conference on Bituminous Coal, Pittsburg*, 1931.
(2) Fuel Research Board. Technical Paper 16.
(3) Fuel Research Board. Report 1920-21.
Fuel Research Board. Technical Paper 26.
(4) *Proc. Inst. Gas Eng.*, 1933-34, **83**, 214.
(5) See Appendix below.
(6) *Gas Journal* (1929), **186**, 793.
American Gas Journal, **129**, No. 3.
Gas Engineers' Handbook, Pacific Coast Gas Assoc., 1934, p. 443.

Appendix.

Distribution of Nitrogen in Coal on Carbonization.

Typical nitrogen content of bituminous coal—
= 1.5% by weight
= 33.6 lb. per ton.

Nitrogen in—

Coke =	1.3% of 12.5 cwt. per ton	= 18.2 lb.
NH_3 =	21.2% of 23 lb. sulphate	= 4.9 ,,
Tar =	1.8% of 14 gall./ton	= 2.7 ,,
		25.8 lb.
	Leaving in gas	7.8 ,,

$$\frac{7.8 \times 386}{28} = 107 \text{ cu.ft.}$$

On 13,000 cu.ft. per ton this gives 0.83% N_2 in gas.
,, 17,000 ,, ,, 0.63% ,,

TABLE IV.—Equilibrium Temperatures of Ammonia in Gas (grains per 100 cu.ft.) in Contact with Liquor of Various Strengths.

Free Ammonia %. NH_3.	50°F.	60°F.	70°F.	80°F.	90°F.
0.22 ...	2	3	5	10	18
0.43 ...	3	6	10	19	34
0.65 ...	5	9	15	29	54
0.87 ...	6	12	19	39	68
1.08 ...	8	15	25	49	84
1.30 ...	9	18	31	59	103
1.52 ...	11	22	37	71	120
1.73 ...	13	25	43	82	140
1.95 ...	15	29	49	93	160
2.17 ...	17	33	56	105	180
2.60 ...	21	41	70	130	220
3.04 ...	26	51	86	160	—
3.47 ...	30	61	102	190	—
3.90 ...	35	72	121	227	—
4.33 ...	40	85	145	—	—
4.76 ...	47	100	172	—	—
5.19 ...	53	116	210	—	—
5.64 ...	58	136	—	—	—
6.06 ...	66	157	—	—	—
6.50 ...	72	180	—	—	—
6.93 ...	80	208	—	—	—

TABLE I.

Reference.	Detail of Test or Authority.	Carbonizing Conditions.	% Steam Decomposed. 7½% Steaming.	21% Steaming.	Between 7½ and 21%.	Per unit Increase at 21%.
A ...	Fuel Research Board, 1920-21	Mitchell Main } Throughput	94	62.5	41.5	32.0
B ...	,, ,, ,, Tech. Paper 15 ...	Holmside } kept ...	70	38	20.2	19.7
C ...	,, ,, ,, ,, ,, 10 ...	South Wales } constant ...	83	47.5	27.5	29.8
D ...	Barash & Tomlinson, *Proc. Third International Conference on Bituminous Coal*, 1931	Wigan Arley. Throughput varied to max.-efficiency	100	59	36.0	36.7
E ...	Test on Lancs. and Yorks. Nuts	Fairly high bottom heats	75	51.5	38.3	36.0
F ...	Do.	Heat higher in retort	75	56.6	46.3	47.4
G ...	Test on above with 20% Unscreened Durham	Fairly high bottom heats	75	45.1	28.5	26.0
H ...	Do.	Heat higher in retort	65	27.7	7.0	*Nil*

TABLE II.

Reference.	Weight of Steam per ton (lb.). 7½%	21%	Steam Undecomposed (lb.). 7½%	21%	Gallons per ton. 7½%	21%	Increase due to Higher Steaming Gall./Ton.
A	168.0	470.4	10.1	176.3	1.01	17.63	16.61
B	168.0	470.4	50.7	292.0	5.07	29.20	24.13
C	168.0	470.4	28.7	247.0	2.87	24.70	21.83
D	168.0	470.4	*Nil*	193.0	*Nil*	19.30	19.30
E	168.0	470.4	42.0	228.0	4.20	22.80	18.60
F	168.0	470.4	42.0	205.0	4.20	20.50	16.30
G	168.0	470.4	42.0	258.0	4.20	25.80	21.60
H	168.0	470.4	59.0	341.0	5.90	34.10	28.20

TABLE VII.—Table showing Equilibrium Temperature in °F. with Varying Free Ammonia Contents of Liquor and Ammonia in Gas.

Liquor Strength % NH_3.	Ammonia in Gas (grains per 100 cu.ft.). 10	20	30	40	50	60	70	80
0.22 ...	80	93	101	108	114	—	—	—
0.43 ...	70	80	89	94	98	102	105	108
0.65 ...	65	73	80	85	86	95	97	102
0.87 ...	57	71	75	80	83	88	90	95
1.08 ...	53	65	72	76	81	84	87	89
1.30 ...	48	61	70	73	77	80	83	85
1.52 ...	—	58	65	71	74	76	80	83
1.73 ...	—	56	62	69	72	74	77	80
1.95 ...	—	53	60	66	70	72	75	77
2.17 ...	—	49	58	63	68	70	73	75
2.60 ...	—	—	55	60	64	67	70	72
3.04 ...	—	—	53	57	60	63	67	69

TABLE III.—Liquor formed on Carbonization by the Internal Reactions in the Coal.

Authority.	Coal.	Liquor produced (Net) Gall./Ton.	% Moisture.	Gall./Ton from Moisture.	Gall./Ton from Decomposition.
Fuel Research Board, Report 1920-21	Consett	10.85	1.51	3.38	7.47
,, ,, ,, ,, 1920-21	Mitchell Main	16.10	1.01	2.26	13.84
,, ,, ,, ,, 1920-21	Lanarkshire Main and Ell. ...	38.00	9.80	21.90	16.10
,, ,, ,, Technical Paper 26	Mitchell Main	19.22	2.50	5.60	13.62
	Average	21.04	3.71	8.29	12.75

TABLE V.—Equilibrium Strengths of Effluent Liquor (% NH_3 free), Assuming Various Rates of Water Flow per 100,000 cu.ft. of Gas with 5 grains NH_3 per 100 cu.ft. at Outlet.

NH_3 in Gas grains/100 cu.ft.	Water Rate, gallons per 100,000 cu.ft. 5	10	15	20	25	30	35	40	45	50	55	60
140 ...	38.5	19.2	12.8	9.6	7.7	6.4	5.5	4.8	4.3	3.8	3.5	3.2
130 ...	35.7	17.8	11.9	8.9	7.2	6.0	5.1	4.5	4.0	3.6	3.3	3.0
120 ...	32.9	16.4	10.9	8.2	6.6	5.5	4.7	4.1	3.6	3.3	3.0	2.7
110 ...	30.0	15.0	10.0	7.5	6.0	5.0	4.3	3.8	3.3	3.0	2.7	2.5
100 ...	27.2	13.6	9.1	6.8	5.4	4.5	3.9	3.4	3.0	2.7	2.5	2.3
90 ...	24.3	12.2	8.1	6.1	4.9	4.1	3.5	3.0	2.7	2.4	2.2	2.0
80 ...	21.4	10.7	7.1	5.4	4.3	3.6	3.1	2.7	2.4	2.1	1.9	1.8
70 ...	18.6	9.3	6.2	4.7	3.7	3.1	2.7	2.3	2.1	1.9	1.7	1.5
60 ...	15.7	7.9	5.2	3.9	3.1	2.6	2.3	2.0	1.7	1.6	1.5	1.3
50 ...	12.9	6.5	4.3	3.2	2.6	2.1	1.9	1.6	1.4	1.3	1.1	1.1
40 ...	10.0	5.0	3.3	2.5	2.0	1.7	1.4	1.2	1.1	1.0	0.9	0.8
30 ...	7.1	3.6	2.3	1.8	1.4	1.2	1.0	0.9	0.8	0.7	0.6	0.6
20 ...	4.3	2.2	1.4	1.1	0.9	0.7	0.6	0.5	0.5	0.4	0.4	0.3
10 ...	1.4	0.7	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
	50°F.	60°F.		70°F		80°F.						

TABLE VI.—As Table V, but with Weak Liquor (0.35% free NH_3 Substituted for Water.

NH_3 in Gas grains/100 cu.ft.	Liquor Rate, gallons per 100,000 cu.ft. 5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
140 ...	38.9	19.6	13.2	10.0	8.1	6.8	5.9	5.2	4.7	4.2	3.9	3.6	3.4	3.1	3.0
130 ...	36.1	18.2	12.3	9.4	7.6	6.4	5.5	4.9	4.4	4.0	3.7	3.4	3.1	2.9	2.8
120 ...	33.3	16.8	11.3	8.6	7.0	5.9	5.1	4.5	4.0	3.7	3.4	3.1	2.9	2.7	2.6
110 ...	30.4	15.4	10.4	7.9	6.4	5.4	4.7	4.2	3.7	3.4	3.1	2.9	2.7	2.5	2.4
100 ...	27.6	14.0	9.5	7.2	5.8	4.9	4.3	3.8	3.4	3.1	2.9	2.7	2.5	2.3	2.2
90 ...	24.7	12.6	8.5	6.5	5.3	4.5	3.9	3.4	3.1	2.8	2.6	2.4	2.3	2.1	2.0
80 ...	21.8	11.1	7.5	5.8	4.7	4.0	3.5	3.1	2.8	2.5	2.3	2.2	2.0	1.9	1.8
70 ...	19.0	9.7	6.4	5.1	4.1	3.5	3.1	2.7	2.5	2.3	2.1	1.9	1.8	1.7	1.6
60 ...	16.1	8.3	5.6	4.3	3.5	3.0	2.7	2.4	2.1	2.0	1.9	1.7	1.6	1.5	1.4
50 ...	13.3	6.9	4.7	3.6	3.0	2.5	2.3	2.0	1.8	1.7	1.5	1.5	1.4	1.4	1.3
40 ...	10.4	5.4	3.7	2.9	2.4	2.1	1.8	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.0
30 ...	7.5	4.0	2.7	2.2	1.8	1.6	1.4	1.3	1.2	1.1	1.0	0.9	0.9	0.8	0.8
20 ...	4.7	2.6	1.8	1.4	1.3	1.1	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.6
10 ...	1.8	1.1	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
		50°F.		60°F.					70°F.						

TABLE VIII.—Relation between Free Ammonia Content of Weak Liquor and Ammonia in Gas (grains per 100 cu.ft.) at Various Equilibrium Temperatures.

% Free NH_3.	50°F.	60°F.	70°F.	80°F.	90°F.	100°F.	110°F.	120°F.
0.20 ...	2	3	4	9	16	26	38	54
0.22 ...	2	3	5	10	18	29	43	61
0.24 ...	2	3	5	11	19	32	48	68
0.26 ...	2	4	6	12	21	35	52	75
0.28 ...	2	4	6	13	22	38	57	82
0.30 ...	2	4	7	14	24	41	61	89
0.32 ...	3	5	7	15	25	43	66	96
0.34 ...	3	5	8	16	27	46	71	103
0.36 ...	3	5	8	17	29	48	75	109
0.38 ...	3	6	9	18	30	51	79	115
0.40 ...	3	6	9	19	32	53	82	120

DISCUSSION

The **President** (Mr. H. H. Thomas) remarked that the Paper described a detailed study of a particular process to which perhaps too little attention had been paid in the past and which, in many instances, was considerably neglected even at the present time. It was an example of the way in which simple matters could be made to pay dividends; in this particular case by conserving steam and the dealing with concentrated ammonia sulphate.

Mr. **E. B. Field** (Blackburn) raised one point in regard to the temperature of the gases at the inlet to the exhausters, which was stated to be between 90° and 100°F. This appeared to be unusually high, though there was probably some good reason for it. He observed that there were water-cooled condensers at the outlet. Why did Mr. Speers work at so high a temperature? If it happened at the Blackburn works he thought that everybody would be called to task.

Mr. **Speers** said that the temperature was intentionally kept high. It enabled the creosote and certain oils to be retained in the gas, thus assisting in the lubrication of the exhausters. The gas was finally cooled at the outlet of the exhausters by water-cooled condensers, thus dividing the cooling process into two sections.

Mr. **Bradshaw** (St. Helens) enquired how long the exhausters had been working under such conditions of high temperature.

Mr. **Speers** replied that this had been so ever since the plant was installed, thirteen years ago.

Mr. **Partington** (Rochdale) asked whether there was special lubrication for the exhausters.

Mr. **Speers** said there was merely creosote.

Dr. **M. Barash** (Ministry of Fuel and Power) said that the Author had referred to an article published by Mr. Tomlinson and himself some years ago embodying the results of an investigation of "steaming" carried out on the Research Gas Plant of West's Gas Improvement Company, Ltd., in which the figures for steam decomposition appeared to be outstandingly high. It might be said that these results were obtained under conditions of greater "technical control per ton of coal" than could be normally exercised in the case of a gas undertaking, so that the results from the Research Department approached more closely to the optimum obtainable. A probable explanation why the published Fuel Research Station corresponding figures were not quite parallel was, as had already been commented in the Technical Press, that in their series of tests the throughput of coal per retort had been kept constant while the C.V. of the gas produced varied.

As many would know who had intimate knowledge of the working of continuous vertical retorts, these conditions were not the best for obtaining optimum yields. Roughly, a constant (depending upon heat input to the system and rate of heat transmission) had to be struck and maintained for any particular installation in the total of coal plus steam passing through the retort, so that if the percentage of steaming was to be increased, then coal throughput must be reduced, and *vice versa*. To obtain a higher C.V. gas (as, for example, for benzole stripping) the coal throughput had to be increased and the steam to the retort correspondingly reduced. The gaseous thermal output of the retort would then remain fairly constant within normal limits of varying C.V. production. If the relative proportions of coal and steam were not correctly adjusted, then output of gas per retort, make of gas per ton of coal, and proportion of steam decomposed were among the main factors which might individually and collectively show serious deterioration.

Mr. **Speers** said that experience at Preston confirmed Dr. Barash's statement. Not only when they changed the amount of steaming, but also when they changed the type of coal, the optimum conditions were altered. The throughput had to be reset in order to obtain an equilibrium.

Mr. **A. E. Ormrod** (Liverpool) proposed a vote of thanks to Mr. Speers, and Mr. **D. Benson** (Bolton) seconded.

Mr. **Speers**, in responding, said that he had referred to the much greater quantities of free water held by small coals.

The **President**, in closing the discussion, had much pleasure in stating that the Silver Medal of the Society of British Gas Industries had been awarded to Mr. J. C. Hogg, a member of the Association, for his Paper entitled "The Treatment of Ammoniacal Liquor on a New Works," which had been read before the Association in 1943.

Heat Treatment of Aluminum and Magnesium Alloys

(*Continued from p. 154*)

The furnace should be close to room temperature at the start and allowed to come to heat slowly, especially after 500°F. is reached. The heating up time should not be less than four hours for alloys like Dow Metal "H" and it is better if five to six hours are used. A general heating up rate of about 100° per hour is suggested.

Another successful user of direct-fired equipment finds it desirable to bring the "H" alloys up to about 675°F. in two and one-half hours and to hold it at that point for about three hours before coming up to the final heat treating temperature. It is self-evident that procedures like these require more furnace capacity and more time for heat treating than the recommendations given in the literature.

The Dow Chemical Company suggests that castings be placed in an oven at 500°F. followed by heating to the heat treatment temperature in two hours.

Results obtained in direct-fired recirculating gas furnaces without SO_2 have been excellent. With proper foundry practice it has been found possible to produce smoother castings of better quality and with higher physical properties, at the same time eliminating sulphur dioxide. There has been no indication of pitting, burning, and no trouble from fire. The value of the slow time of heating including, if, necessary, a period of soaking slightly below the heat treatment temperature in getting the Zn-Mg eutectics into solution is borne out by recent studies of the metallography of the commercial magnesium alloys.*

While single instances of fire do not have great significance, it is noteworthy that several foundries using electric equipment and sulphur dioxide have suffered fire losses. Thus far there have been no fires reported from foundries using direct fired gas furnaces, without SO_2 protection.

The heat treatment of "C" alloy castings in direct fired gas furnaces without SO_2 is also practical, but these alloys apparently require more careful treatment than the "H" alloy to prevent damage or fire. Information made available to the Committee from field tests made at four foundries in New York and New Jersey indicates that no trouble will be experienced in the heat treatment of "C" alloy castings in direct gas-fired furnaces, provided that the heating rate is kept down to a rate of temperature rise of 50°F. per hour or less. This becomes most important when the temperatures are between 500°F. and the heat treating temperature. It is recommended that "C" alloy castings be heated by setting the furnace up 25°F. every 30 minutes. The advantages of "C" metal for permanent mould castings will probably tend to increase the use of this product as additional work is undertaken with permanent moulds.

Records made available to the Sub-Committee indicate that foundries using these techniques for "H" and "C" alloys have an exceptional record for fine quality products free from any evidence of bubbling, powdery black spots or other defects associated with local oxidation or overheating. Reject percentages appear to be practically zero in so far as the heat treating is concerned, and without doubt it is the heat treatment of magnesium alloy castings which constitutes the principal point where quality can be easily damaged. The objection to slower heating rates is self-evident since it requires somewhat more time and more heat treating equipment, but it should not be difficult to lay out a foundry in which the heat treating facilities exceed the casting production without using up undue amounts of valuable space.

Unfortunately, the segregation of zinc in the casting is not a fixed and uniform effect so that there may be some individual castings which are adversely affected by a given heat treating cycle although the bulk of the material would be all right.

Oxidation or incipient fusion generally shows up in the surface appearance of the castings. Black powdery spots or eruptions or metallic beads appearing after the solution heat treatment has been completed furnish indication that the temperature has gone beyond safe levels at least locally. This should be followed immediately by a check or recalibration of the furnace temperature controls. It might also be desirable to make sure that the furnace loading permits perfectly uniform temperatures. Variations in excess of plus or minus 10°F. should be considered excessive. Not only is immediate action called for because of the destruction of individual castings, but the condition indicates that serious fire hazard exists since the local destruction of parts of a casting may readily lead to temperature rises sufficiently to set it on fire.

Upon completion of the solution heat treatment, the work is taken out of the furnace and allowed to cool rapidly in the air. The greater part of the alloying constituents remain in solution because they are not affected by the rate of quenching to the degree shown by aluminum base alloys. However a load of castings permitted to cool in still air will be inferior to one quenched in moving air or an air blast. A water quench is not advisable because of the risk of producing cracks in the castings.

When the castings are cool, they may be given a precipitation treatment or ageing treatment. It is not necessary that the castings be absolutely cold, but they should be cool enough to handle, say, at

* "Metallography of Commercial Magnesium Alloys," J. B. Hess and P. F. George, *Trans. of the A.S.M.*, June, 1943 (see especially pp. 439, 442 and 443).

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temperatures not exceeding 150° F. They can then be returned to the same furnace if no other is available and treated for 12 to 20 hours at 350°F. This treatment will produce maximum hardness and yield strength although at some sacrifice of elongation.

Wrought magnesium alloys are not usually given a solution heat treatment since working them has tended to produce a state that develops good physical properties. However, they are occasionally aged to develop hardness and yield strength.

Sulphur Dioxide

Sulphur dioxide has been generally recommended as a protective atmosphere for heat treating magnesium castings. The amount used is such that the concentration in the furnace is kept between several tenths and 1% of SO_2 in the furnace atmosphere. The exact amount is not important as long as continuous SO_2 additions are maintained to make up for the loss from air infiltration. The purpose of adding SO_2 is to provide a means of protection against local oxidation and to reduce the chance of fire in event of an override of the furnace temperature or due to failure of the thermostat. SO_2 appears to be a satisfactory inhibitor of local oxidation up to about 800°F.

The objections to SO_2 in the furnace are numerous:

(1) SO_2 is irritating to workers.

(2) It will attack metals, particularly if they are damp, and its destructive effects are readily seen in any foundry using it. Since it has been widely used with electric furnaces for fire protection, mention may be made of its effect in reducing the life of resistors and other electric equipment.

(3) Furnaces in which SO_2 has been used cannot be used for the heat treatment of aluminum alloys because of the difficulty in purging all of the SO_2 from the furnace. If any is allowed to remain, it will vigorously attack wrought aluminum alloys, and to a lesser extent cast aluminum alloys.

(4) It adds to the cost of heat treatment.

(5) It furnishes a false sense of protection.

The first decision which a prospective user of gas furnaces for magnesium heat treatment must make is whether to use indirect or direct gas heat. If indirect furnaces are selected, it is probable that the recommendations regarding the use of protective atmospheres, either sulphur dioxide or other protective atmosphere, should also be followed.

If a direct-fired gas furnace is selected it should be of the recirculating type, so designed that uniformity of temperature is assured and so equipped that the rate of temperature rise can be controlled within the desired limits. In light of the recent experience with "C" alloys it might also be desirable to consider the use of time and temperature controllers so that control of the heating rate could be made automatic. Fears expressed regarding the use of direct flue gas atmospheres has not been borne out in practice.

At the present time, highly successful heat treatment of magnesium castings is carried out in direct-fired recirculating gas furnaces in at least eight well-known magnesium foundries in the United States.

Lighting the Homes of To-morrow*

By J. B. CARNE, B.Sc.

HOME lighting has been the subject of Papers and discussions before our Society on many occasions in the past. The lighting of the home, in which economy dominates the provision of necessities and amenities, has, however, in the Author's opinion, seldom received the attention it deserves. Social surveys made during the past 20 years clearly show that the majority of homes in the country fall into this category—a fact which alone justifies special consideration of the problems concerned.

In the following treatment attention is centred on the artificial lighting of these homes. It should not be overlooked that the principles involved are as applicable to the rich as to the poor home, and that the suggested provisions for lighting might well serve as the basis for the lighting of homes of all classes.

Prospective considerations often lead us to the fanciful, but if we are to profit by such considerations, reality must never be left far behind, and if we are to assess the true worth of the conclusions derived, we must view them in perspective with related considerations.

For these reasons it is proposed to deal somewhat circumstantially with "to-morrow" and "the home" before presenting the data on lighting, which is the expected feature of a Paper before our Society.

"To-morrow"

First let us consider the special nature of the period with which we are concerned. The "to-morrow" we contemplate is the day when building a house ceases to be an indictable offence and becomes priority A1. We foresee it as a period of unprecedented opportunities coupled with unprecedented facilities, the day after battle—a time long regarded appropriate for improving the homes of the people. In 1843 the appalling housing conditions in some of our cities stimulated organized effort in slum clearance and rehousing. Pioneer work began in Liverpool at this date and housing improvements have been continued since, except during the world-war periods, on either small or large scale. Between the wars approximately four million homes were built in this country, representing the rehousing of a quarter of the population. There was for this record building no grand programme such as is now contemplated for the construction of a similar number of houses in a shorter period, and the lighting equipment which went into the major portion of these houses was regarded more as a selling feature than a necessity, ranking with a pure water supply and good sanitation. The second report (1) on Codes of Practice for building and civil engineering lead one to believe that in magnitude and comprehensiveness the plans for our to-morrow go far beyond anything of the kind yet formulated. Planning for to-morrow extends from that of town and country to the washer on the kitchen tap, aye, and to the lighting units for the home. Not for nothing, then, have post-war planning committee rooms buzzed and bookstalls creaked under the welter of reports and replanning literature. Let if be hoped that the cumulative effort and enthusiasm of reformers and designers since the days of Richard Elsam in 1816 will reap full reward. That lighting in the home is officially recognized as a basic amenity and is to be the subject of a code of good practice are facts which must be gratifying to our Society. Records show that from its earliest days the Society has paid attention to home lighting. Its Code has, since its inception, included a section on recommended values for the home. For the most recent expression of interest one has only to refer to Mr. Ackerley's Presidential Address of 1942, in which he urged "diffusion of light," particularly in the great field of the "community at large."

"The Home"

It is understood that the building of four million homes and the reconditioning of eight million existing ones constitute the immediate post-war domestic building programme. These, then, will largely determine the average home of to-morrow, and are therefore the homes with which this paper is concerned. How well can they be lit? What of the average home of yesterday? How well was that lit?

When discussing standards and the methods of attaining them, reality demands that we take account of the economics involved. Where costs are concerned we cannot "slink round the corner murmuring, 'They have nothing to do with us.'" Such an attitude would be as equally irresponsible as that of a dietary adviser who would refer the housewife to "Mrs. Beeton" as a guide to wartime catering. The obligations of the lighting engineer in this respect are no less than those of the architect, who must plan according to the income of the prospective tenant.

What, then, are the relevant economics of the average household, and what were the lighting conditions in the average houme of yesterday?

In trying to visualize the average home we must avoid making the common error of imagining our own particular home as approximating to the average. I have therefore drawn the following relevant data, set out in Table I, from official statistics and accepted authorities:

TABLE I.

Source of data.	Class of home.	Average household income per week.	Average number in household.	Average number of rooms per household, excluding scullery and bathroom.	Average amount per household spent on light and fuel per week.
New Survey of London Life and Labour(2) 1929-30	Av. of 82% of working-class homes in London, 1930	£ s. d. 3 18 0	—	—	—
Investigation for cost of living index computation(3)	Av. of 8,905 N.H.I. industrial workers in G.B. 1937	4 5 3	3.8	3.9	6s. 5d.
Investigation for cost of living index computation(4)	Av. of 1,491 agricultural workers in G.B. 1937	2 17 11	3.8	4.0	4s. 11d.
Investigation for cost of living index computation(5)	Av. 366 rural working-class in G.B. 1937	2 16 8	4.25	4.3	4s. 9d.
A handbook of statistics(6)	Av. income 75% of total number of families in country 1937	Less than £4 per week	—	—	3s. 6d. to 5s. 6d.

Mr. Seebohm Rowntree (7) (8), the well-known sociologist, gives the following subsistence budget for a family of five in the autumn of 1936:

	s.	d.
Food	20	6
Rent	9	6
Clothes	8	0
Fuel and light	4	4
Household	1	8
Personal	9	0
	53	0

In analyses of family budgets the expenditure on lighting is invariably included in an amount covering "fuel and light." From an analysis(9) of the hourly gas output records of the South Metropolitan Gas Company it is possible to compute with some degree of accuracy

* From a Paper to the Illuminating Engineering Society.

average data on the lighting of 300,000 domestic consumers' premises in South London in 1931. These are as follows:

Hourly gas rate for lighting (1931) per domestic consumer.	Gas consumed per week for lighting. Average for year of domestic consumer.	Light-output of source corresponding to average gas consumption. (Non-superheated burner.)
2,500 B.Th.U./hr.	0.55 therm	936 lumens (corresponds to the output of between 1 B.S.4 and 1 B.S.4+1 B.S.1 burners).

A recent survey of 1,600 households (in which principal wage earners' wage was less than £5 per week) using electric lighting, made by the Wartime Social Survey on behalf of the Department of Scientific and Industrial Research, provided the following data, which the Author is permitted to quote:

Room.	Average size lamp in use.*	Types of shade in use. Expressed as proportion of total surveyed. Simple conical shade with bulb showing below.	Translucent bowl.
Working kitchen	40-watt	86%	10%
Kitchen livingroom	60-watt	72%	14%
Livingroom	60-watt	60%	21%

* In one-third of dwellings the size of lamps had been reduced since the war.

Study of the gas output curves referred to show that the average annual number of lighting hours per household is approximately 1,100.

Based on the foregoing data calculation shows that the cost of lighting to the average householder was an amount less than 40s. per year, or 9.2d. per week. The actual figure depends on the cost of fuel energy to the householder; the maximum quoted corresponds to fuel energy prices of 18d. per therm for gas and 6d. per unit for electricity.

The interdependence of the components of the household budget and the necessity for examining costs in domestic planning are only too well demonstrated by the following report [10] on an actual but what is hoped a rare case:

> "In a famous investigation some years ago into the effect of removing slum-dwellers from the centre of the comparatively small town of Stockton-on-Tees (70,000 inhabitants) to a new suburb on the outskirts, it was shown that the extra cost, in hard cash alone, of the amount of additional travel required of the workers was such as to lower definitely the standard of living and to increase quite shockingly the rate of mortality and the incidence of disease."

These data and quotations indicate that the average family budget allows little surplus money to meet the cost of higher standards in the basic necessities of life, and the approach to our problem must be made accordingly.

The following extract from the report [2] of the Council for Art and Industry indicates clearly the type of decorations prevailing in the average home:

> "We have been especially concerned by the tendency towards dull and heavy colour schemes, both among individuals and among local authorities who are responsible for decoration in the new estates. We were advised on several occasions that the general choice tended towards brown or towards a set of colours which has been described as the gravy colour scheme."

The term "lighting" covers not only the objective but also the subjective effects. It covers the illuminating performance and the visual effects.

Visual effects, the aim and the criterion of excellence of every lighting installation, depends in the home on illuminating performance of the lighting units, room decoration, and design of the units. The latter two factors, although less precisely definable than the former, are nevertheless equally important. In considering them we encounter that personal property, taste, and so reluctant are we to trespass on the freedom of the individual that some may feel that to limit in any way the choice of decoration or design in the home is to violate a basic rule of our constitution. Even so, it must be admitted that there are good and bad tastes, and that education, especially by example, can play a great part in developing the good.

Fortunately, what can be regarded in decoration and design from our point of view as good is little, if any, more costly than bad, and for this reason these lighting factors will be dealt with before illumination levels and the performance of units.

Lighting engineers have for many years stressed the value of light-coloured decorations for interiors. Such decorations not only give considerable aid to comfortable seeing by reducing contrast between parts of an interior and between the unit and its background, but they are essential to the creation of the bright environment, which has proved to be important to the maintenance of good health. The contribution to the illumination intensity which a light interior makes depends, of course, on the proportion of the direct and indirect light from the unit used. Except when a markedly indirect unit is employed this contribution is not large, but even so it is sufficient to improve diffusion and soften shadows to a marked degree. Consideration shows that the smaller the interior the greater the influence of interior decoration on the lighting effects, and thus in dealing with home lighting special attention is due to this part of our problem.

Comparison of the utilization factors for various interiors, as set out in the tables used for design calculations, enable some idea to be formed of the effect of walls and ceilings on the horizontal illumination. Considerably more, however, is to be learned from calculations of the lighting of an average size room, which can be made provided certain approximations are conceded.

The data given in Table II refer to a room the walls of which were firstly "coral rose" (R.F. 62%) and secondly black (R.F. 2%), and the ceiling white (R.F. 76%) and then brown (R.F. 27%).

Room dimensions, 14 ft. 6 in. by 16 ft. by 8 ft. 8 in.

Lighting unit central, 6 ft. 6 in. above floor.

Source output, 1,850 lumens.

When allowance is made for the differences in the output, reflection factors, &c., in the two sets of conditions, we can show the relative effects of the contribution of indirect light in the cases of "direct" and "general" types of unit.

The reflection factors of "gravy" colours are of the order of 15%. The actual waste of light due to using "gravy" coloured as compared with pale shade walls is at least 10%.

TABLE II.

Type of unit and output.	Walls. Reflection factor.	Walls. Brightness.	Ceilings. Reflection factor.	Ceilings. Brightness.	Average horizontal illumination, foot-candles.	Difference in contribution to horizontal illumination. % of total.
Direct unit	62%	0.8 e.f.c.	76%	1.2 e.f.c.	5.8	
	2%		76%		5.6	Walls 4%
1,550 lumens	62%		27%		5.2	Ceiling 10%
	2%	0.07 e.f.c.	27%	0.26 e.f.c.	5.1	
General	62%	1.7 e.f.c.	76%	2.8 e.f.c.	3.6	Walls 14%
	2%		76%		3.1	Ceiling 22%
1,450 lumens	62%		27%		2.8	
	2%	0.14 e.f.c.	27%	0.84 e.f.c.	2.5	

All lighting considerations lead to the condemnation of the popular "gravy" colour scheme. The argument that such a scheme keeps cleaner is, of course, false; light colours, in fact, encourage cleanliness by revealing dirt. Perhaps the most satisfactory compromise with this attitude is effected by having the dado a dark colour and the filling a colour of light shade.

Effect of Floor Reflection Factor

In the average home the smallness of the free floor area in furnished rooms and the necessary use of floor coverings which are not easily marked tend to minimize the effect of the floor on the utilization of light. The economical use of house space is receiving the studied consideration of architects, and it is not unlikely that we shall see a wide adoption of the home plan containing one large living room for the family communal life and bedsitting rooms for the quiet use of the individual, in which eventuality the floor effect becomes worthy of mention. As a result of experimental investigation Lansingh [11] drew the following conclusions on the interaction of walls and floors so far as illumination at table top level is concerned:

(1) With walls and floors, both 55% R.F., there is an increase on the working plane of 50% above what is obtained with walls at 11% and floor 2%.

(2) The maximum increase obtainable from increasing R.F. of walls only is 25%.

(3) The maximum increase obtainable from increasing R.F. of floor only is 15%.

One does not have to be subject to claustrophobia to experience a distressing irritability when confined in a small room. The rooms in many of the houses and flats built in the "between-wars" period are undersized, and it is not at all improbable that as a result of a misguided policy of economy in building, the near future will see the number of such rooms greatly increased. Any means of alleviating the discomfort of those whose lot it is to occupy miniature rooms warrants attention, and the following subjective effects associated with lighting may be well worth exploiting.

A room appears smaller when its walls are glossy than when matt, and large patterns in dark colours also reduce the apparent size of a room as compared with the appearance with a plain light-coloured wall decoration.

Another effect which has practical application in the "make-do-and-mend" programme, in which as a result of dividing large rooms the smaller ones formed may have ceilings disproportionately high in relation to floor area, is that a ceiling darker in colour than its surrounding walls appears lower than when the reverse condition obtains. The extreme condition of this effect is the well-known "tunnel" effect experienced with totally direct lighting.

Design of Units

Excepting the crudest types of shades, good designs are cheaper than bad. We are still near enough to the 19th century to meet articles of that period daily, and to find in many of recent production that excess of ornament which was the predominant characteristic of fashion and design of the Victorian age. The sophistication of popular taste resulting from the sudden material wealth which followed the industrial revolution markedly influenced the design of lighting fittings and units, even to this day. In the absence of well-defined principles of good lighting, ornamentation ran riot frequently at the expense of good performance.

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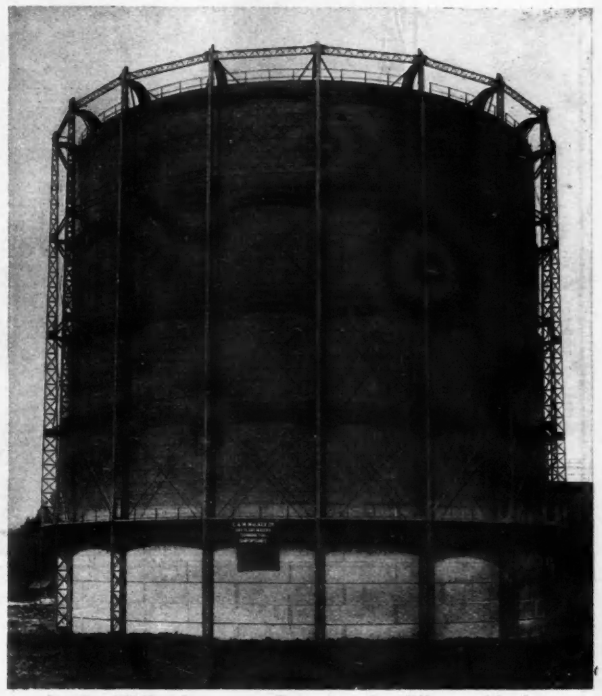

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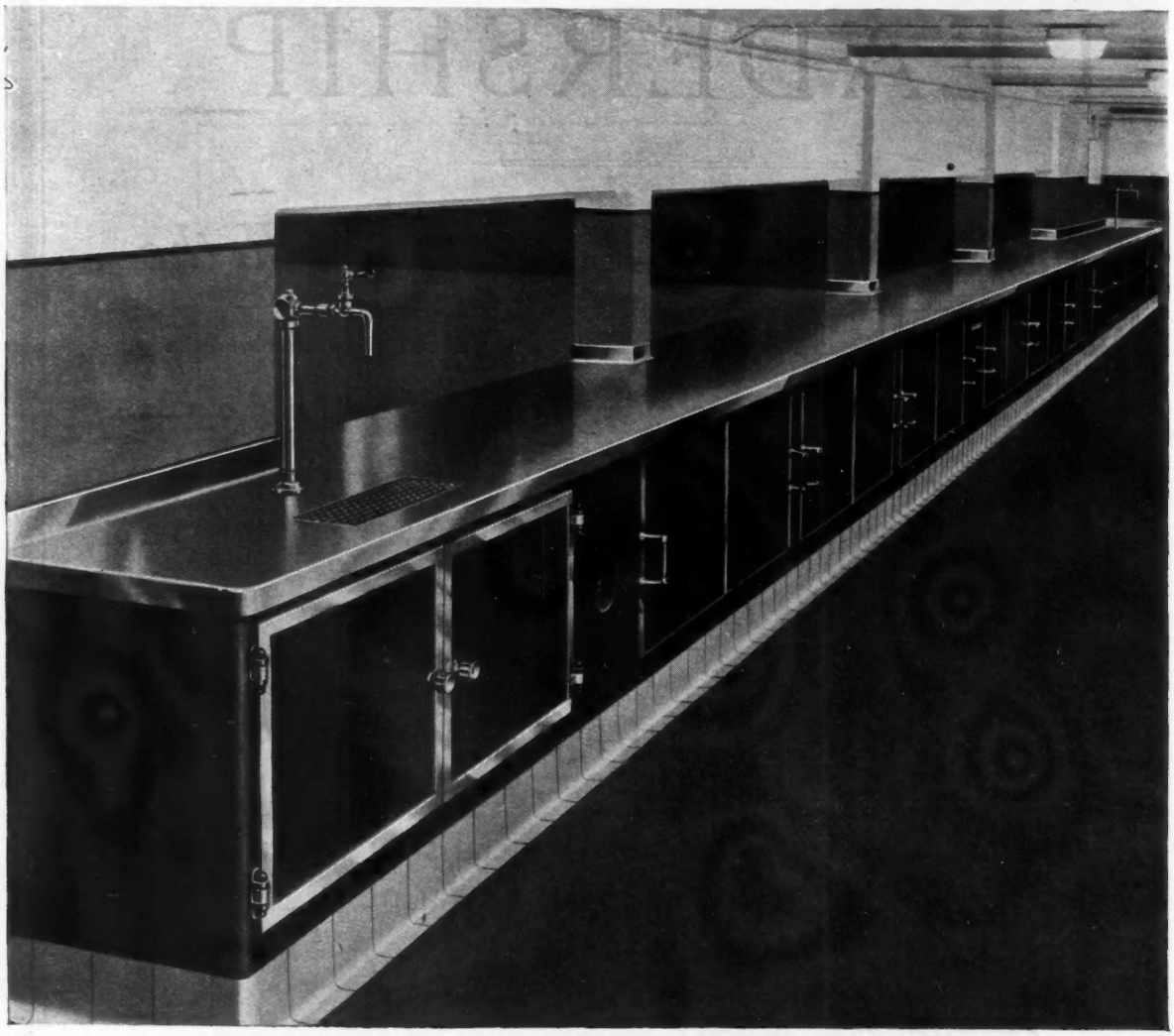

A view of the Women's Service of a large Canteen Kitchen equipped by

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A properly designed unit is the major factor in ensuring the practice of good lighting, and it is this which is lacking in most homes. Here, then, the lighting engineer can make a real contribution to good homes of to-morrow, for you cannot have "functionalism" in lighting unit design without a lighting expert—the principles of good lighting are too readily forgotten by anyone else. But "functionalism" is a narrow basis for design, and I cannot conceive a basis more generous and appropriate than Ruskin's dictum: "Truth first—plan, or design, founded thereon." Our scientific investigators have, by elucidating the main principles of good lighting, supplied the truth in our problem and in its solution; the distribution and degree of illumination, the brightness of surfaces, durability of performance, are all pertinent subjects for truth. How few units there are which can claim these in truth to be their basis! Is not the truth of them mostly subordinated to the densely coloured panel, the arty shape, the oversize tassel, or the metal scrollwork?

Here, then, is need for the co-operation of the lighting expert, the designer, and the manufacturer, to all of whom the Author suggests, for guidance, again the advice of Ruskin—advice which he gave more than half a century ago to the manufacturers of Bradford (12). "We require work substantial rather than rich in make, and refined rather than splendid in design. Your stuffs need not be such as would catch the eye of the duchess, but they should be such as may at once serve the need and refine the taste of a cottager." A policy which it has taken the privations of total war to make us adopt in the production of the essential articles of life, for is not this the basis of design of "Utility" goods? The suggestion is here put forward that representatives of our Society, of a recognized design authority, and of manufacturers should get together and produce "Utility" home lighting units, which are essential at the same time to the economical use of fuel energy and to the attainment of cheerful environment and good seeing in the home.

The availability of such units, purchasable free from tax, would, in the Author's view, do more to raise the future standard of home lighting than any other single factor.

Truth implies, among other qualities, efficiency; for a unit which belies the source cannot claim to be truthful in design. In adopting Ruskin's basis for design we have two main characteristics to satisfy—"functionalism" and "efficiency," on both of which depend economy.

The unit, therefore, should, in conjunction with its surroundings, provide a level of illumination adequate for the tasks to be performed; it should present a brightness, both in itself and its surroundings, which in no normal circumstances is discomforting and which promotes the mental attitude desired. In addition, the light from the source should be utilized consistently to these ends in an efficient manner. This last requirement involves such technical matters as minimization of maintenance, accessibility of parts, and ease of assembly.

Success in the attainment of these desiderata depends, of course, on suitable materials for the making of units and on the sources available. The scope of designers will be considerably widened by the availability of new plastics and the fluorescent tube. Some time will elapse before such new articles will be commonly found in the home under consideration, but it is not likely to be unduly long, for the lag between the completion of an invention and its use in the home is negligible compared with the lag between the establishment of a principle and its practice in the home. Compare, for instance, on the one hand, the rapid entry into the average home of the incandescent gas mantle, the incandescent electric filament lamp, or the triode thermionic valve—only a few years elapsed between their creation in the laboratory and their common use. On the other hand, we are still waiting for the implications of Newton's "law of cooling" to be appreciated and acted upon by the builder who lays the exposed pipe under the kitchen floor, and for the lesson of the "Black hole of Calcutta" to be learnt by those who construct unventilated bedrooms.

It is therefore principles with which we must be mainly concerned, for once they are appreciated and applied by user and designer alike, the best use will be made of novel materials and sources, from wherever they may come.

The room in which a unit is to be used must be considered when judging the excellence of the unit from the point of view under discussion. A spherical globe unit may be of excellent functional design for a kitchen or other room in which only a moderate intensity of illumination is required at all parts. On the other hand, a unit with a relatively greater downward component for local lighting over a sink would meet the demand for "fitness of purpose."

Improvements and Costs

In the average home the decorated shades and bowls in common use have output efficiencies of the order of 60% and 50% of the same outputs respectively. Assuming the "gravy" colour wall decoration and an output of the source of 750 lumens as deduced earlier, calculation shows that in a room approximately 13 ft. square, the average illumination prevailing in the living rooms of yesterday's home was approximately 2.5 ft.c., with a table average of 6 ft.c., and the area beyond that covered by the direct light from the unit having an average of the order of 0.5 ft.c.

Substitution of the 60% efficient shade by a different type and redecoration of the walls with light colours would raise the minimum illumination to nearly 1 ft.c., improve diffusion, reduce glare, and increase the wall brightness eightfold.

To provide the levels of illumination recommended in the I.E.S. Code sources of greater luminous output and additional units for local lighting are required near the sink and the bed heads, as well as plug-in-points in the living room and bedrooms for standard floor or table-lamp connexion.

It is hoped that implementation of recommendations made in Codes and Practice will be general, and thereby ensure the provision of an adequate number of lighting points and the installation of efficient units. The use to-morrow of sources which consume more energy, and are therefore more costly to run, will of course be the prerogative of the householder. Reference to the average "working-class" household budgets quoted earlier in this Paper might lead one to suggest that a surplus shilling could be found in them to meet the increased cost entailed in raising yesterday's levels to those of the I.E.S. Code. However strong and convincing a case could be made to justify this expenditure, one cannot doubt that an equally strong case could be made for using that shilling to raise the standard of other necessities of life. Excepting the availability of cheaper light to the consumer, there appears little prospect of illumination levels in the principal rooms of the homes of to-morrow being little more that half those recommended in the I.E.S. Code, while as far as quality is concerned there are good grounds for anticipating a considerable improvement on yesterday's practice.

Costs of lighting to provide a given average intensity of illumination by the three main systems, "direct," "general" and "indirect," are obviously inversely proportional to the utilization factors of the three systems. Approximately these are in the ratios 1 : 0.7 : 0.5, and thus the relative cost for energy to provide a given average intensity are in the ratios 1 : 1.4 : 2. In actual practice, owing to the more comfortable quality of illumination resulting from the general and indirect units, such illumination, even with a lower average intensity, is generally preferable to a higher average provided by a direct unit. Accepting some adjustment for this advantage of quality, the energy ratios become approximately 1 : 0.85 : 0.6 and the cost ratios of the three systems 1 : 1.2 : 1.75, or, in other words, lighting by general and indirect units is approximately one-fifth and three-quarters respectively dearer than by the direct unit.

Reduction to the householder in the cost per lumen, which is most likely to result from the introduction of the fluorescent tube, would, it seems from past experience, be followed by the use of higher illuminations.

Higher levels of illumination in the home have always accompanied the use of more efficient light sources; for when a householder changed from the flat flame to the incandescent mantle, or from the carbon to the tungsten filament lamp, he did not reduce his light bill to maintain the old level of illumination, but rather did he maintain his bill and increase his illumination.

Education by precept and example will no doubt tend to induce those who can well afford to do so to use higher consumption sources, and thus higher levels of illumination.

A prediction has been essayed of the lighting of the average home in the years immediately following the war. In such a critical period lighting engineers and others concerned with this small but important feature of post-war planning should be fully cognizant of the essential details bearing on the problem, so that they may, whenever the opportunity arises, add their measured strength to the forces for improvement.

Summing up, it appears that considerable improvement in the quality of lighting will materialize, but this only through the sustained efforts of all those who appreciate the problems involved. How close the levels of illumination will aproach the I.E.S. recommended standards of good practice depends in the main on the economics of the household budget.

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(12) *The Two Paths.*

The fact that goods made of raw materials in short supply owing to war conditions are advertised in the "Journal" should not be taken as an indication that they are necessarily available for export.

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GAS PRODUCTS PRICES—STOCKS AND SHARES

The London Market Aug. 7.

A Government Order came into effect on March 1 controlling the price of Benzole and Coal Spirit and replacing the Control of Coal Tar Naphtha and Xylole Order, 1943.

The Order is known as the Control of Benzole and Coal Spirit Order, 1944 (S.R. & O. 1944, No. 172).

By this Order the price of Motor Benzole is fixed at 2s. per gallon. The Order also lays down the method of evaluating Crude Benzole.

The Order also calls for periodical returns to the Ministry of Fuel and Power from all producers of Crude and Refined Benzole.

The only item of interest in connexion with the Coal Tar products market is the issue of Government Order designated the Control of Toluene (No. 4) Order, 1944 (S. R. & O. 1944, No. 170), which contains an amendment of the Control of Toluene (No. 3) Order, 1943.

Prices of Coal Tar products are unchanged.

The Provinces Aug. 7.

The average prices of gas-works products during the week were: Pitch and Crude Tar,* Toluole, naked, North, 90's, 1s. 11d. to 2s. 1d., pure, 2s. 7½d. (controlled by the Control of Toluene No. 3 Order, dated July 14, 1943, operative from July 20, 1943). Benzole and Coal Spirit, also Coal Tar Naphtha and Xylole, are now controlled by the Control of Benzole and Coal Spirit Order, 1944, dated Feb. 18, 1944, S. R. & O. 1944, No. 172, operative from March 1. Carbolic acid, 60's, naphthalene, anthracene, creosote oil (hydrogenation), coal tar oils (timber preservation, &c.), and strained anthracene oil controlled by the Coal Tar Products Prices Order, 1943, dated Oct. 20, 1943 (S. R. & O. 1943, No. 1528), operative from Nov. 15, 1943.

* In regard to pitch and crude tar prices we would ask readers to refer to the editorial note on p. 396 of the "JOURNAL" for Sept. 10, 1941.

Scotland Aug. 5.

Deliveries are well maintained despite the holiday period. Refined tar*: Yield to distillers is 4½d. per gallon *ex* Works, naked. Creosote oil: Timber preserving quality,* 5½d. to 6½d.; hydrogenation oil,* 5⅞d.; low gravity or virgin oil,† 7¼d. to 7½d.; benzole absorbing oil,* 6½d. to 8d. per gallon. Refined cresylic acid* is 3s. 6d. to 4s. 6d. per gallon *ex* Works, naked, according to quality. Crude naphtha†: 6½d. to 7d. per gallon. Solvent naphtha*: Basic prices delivered in bulk, 90/160 grade, 2s. 8d., and 90/190 Heavy naphtha, Unrectified, 1s. 10½d.; Rectified, 2s. 2d. per gallon. Pyridine†: 90/160 grade, 13s., and 90/140 grade, 15s. per gallon.

* Price controlled. † Uncontrolled.

The good war news coupled with the Prime Minister's optimistic statement were favourable influences in the stock markets last week. The demand for gild edged and industrials continued until nearly the close, when the holiday atmosphere prevailed and the volume of business tailed off.

Conditions in the Gas Market were practically unchanged and prices remained firm. It will be seen below that with the exception of Alliance and Dublin ordinary, which closed 10 points higher at 115, there were only a few minor changes, the majority of which were in an upward direction.

There is not a wide choice of gas stocks available at the present time, and those on offer are mostly confined to the larger undertakings, but these do yield in most cases and with good security well over 3%. Among ordinaries, Gas Light units on a 4% basis at 23s. 6d. yield £3 8s. 1d., South-Eastern Gas Corporation at 21s. 6d. yield £3 14s. 5d., Southampton at 107 returns £4 13s. 5d., and United Kingdom at 22s. yield £4 10s. 11d.

The following price changes were recorded during the week:

PROVINCIAL EXCHANGES

Bristol 1st 4 p.c. Deb.	101—103	+1
Ditto 2nd 4 p.c. Deb.	101—103	+1
Newcastle Units (*x.d.*)	25/6—26/–	July 31
Ditto 4 p.c. Pref. (*x.d.*)	99—101	"
Sheffield Cons.	144—145	–1

OFFICIAL LIST

Alliance & Dublin	110—120	+10
Cape Town 4½ p.c. Cum. Pref. ...	6¾—7¼	+¼
Gas Light Units (*x.d.*)	22/6—23/6	July 31
Ditto 3½ p.c. max. (*x.d.*)	78—81	"
Ditto 4 p.c. Pref. (*x.d.*)	98—101	"
Imperial Continental 3½ p.c. Red. Deb. (*x.d.*)	97—100	"
Primitiva Holdings Ord.	8/—10/–	–/1–
Severn Valley Gas Corporation Ord.	22/—23/–	+–/3d.
South-Eastern Gas Corporation Ord.	20/3—21/3	+–/3d.
South Metropolitan Ord.	89—92	+1
South Suburban Ord. (*x.d.*)	112—117	July 31
Ditto 5 p.c. Pref. (*x.d.*)	107—112	"
Ditto 4 p.c. Pref. (*x.d.*)	96—101	"
Ditto 3½ p.c. Red. Pref. (*x.d.*) ...	90—95	"

SUPPLEMENTARY LIST

Cambridge "B" (*x.d.*)	140—145	July 31
Croydon 4 p.c. Pref.	95—100	+2

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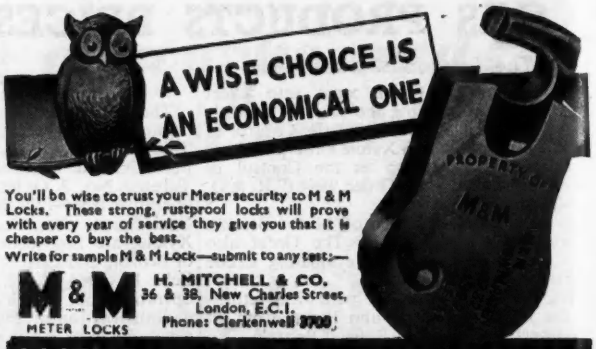

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The Salary offered for this appointment will be at the rate of £500 per annum inclusive of cost-of-living bonus at the date of appointment.

Further particulars may be obtained on application to the undersigned. Latest date for receiving final applications is September 2, 1944.

Council Offices, Prestatyn. J. LLOYD HUGHES, Clerk of the Council.
August 4, 1944.

(Continued on p. 192)

APPOINTMENTS VACANT (ctd.)

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H. HOPKINS,
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Gas-Works,
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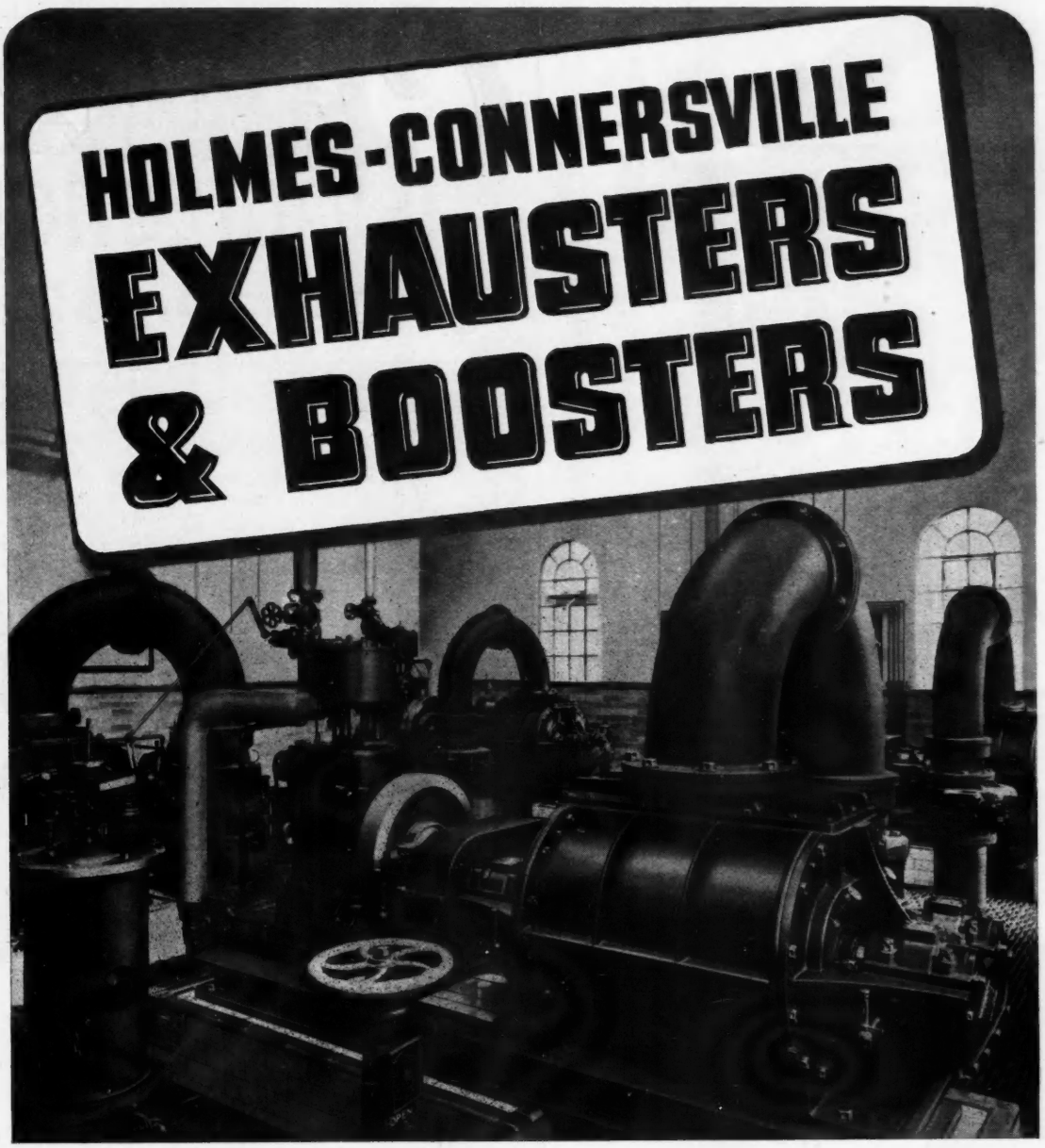

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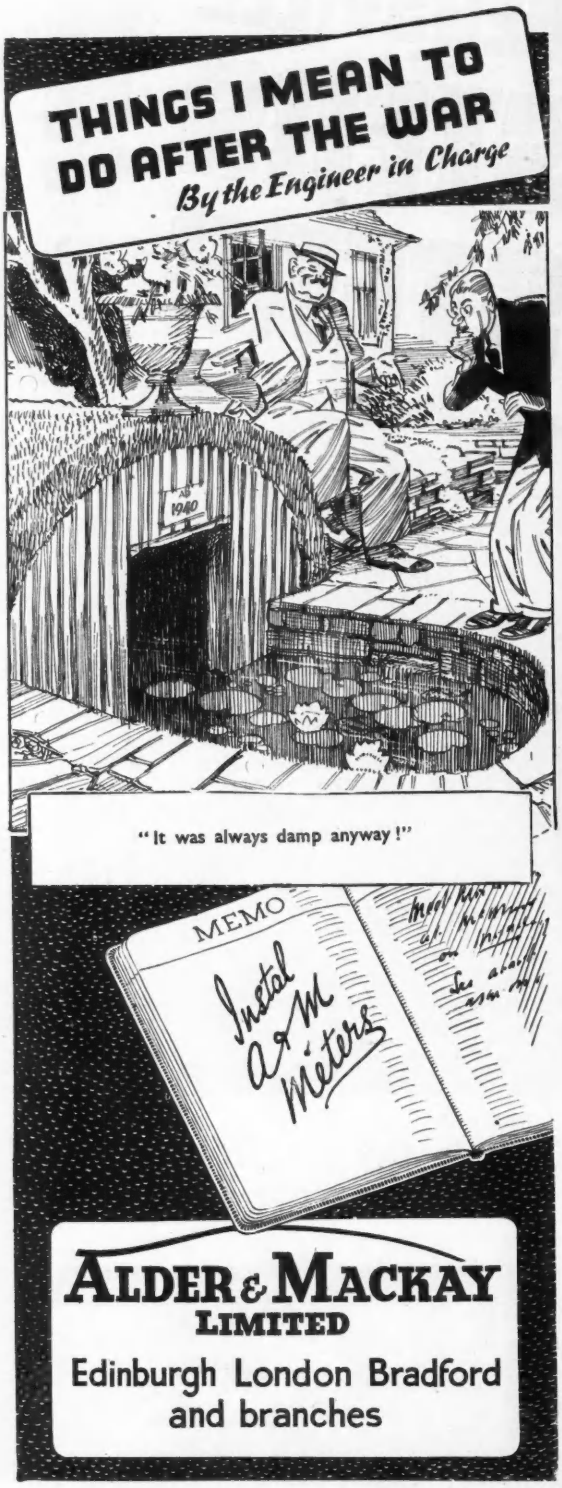

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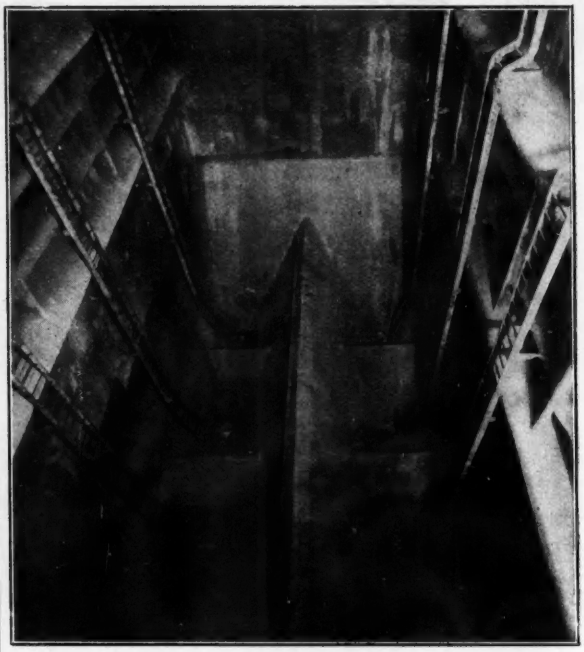

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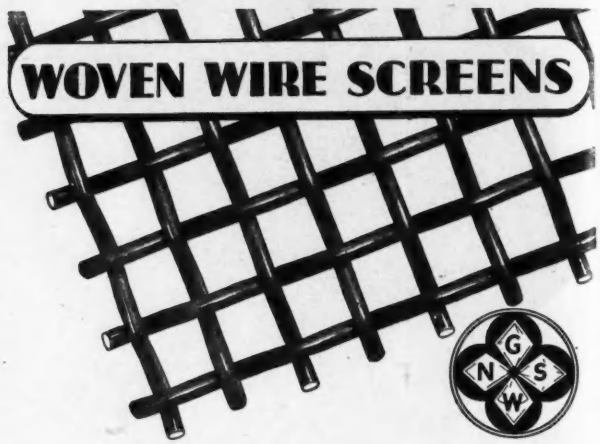

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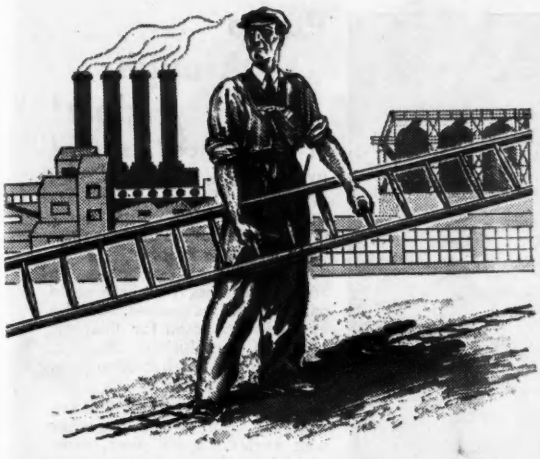

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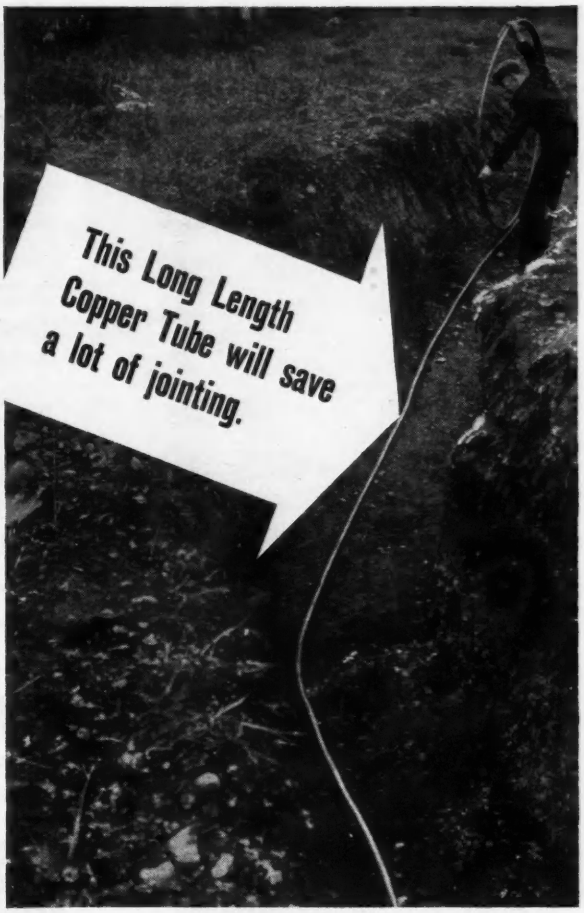

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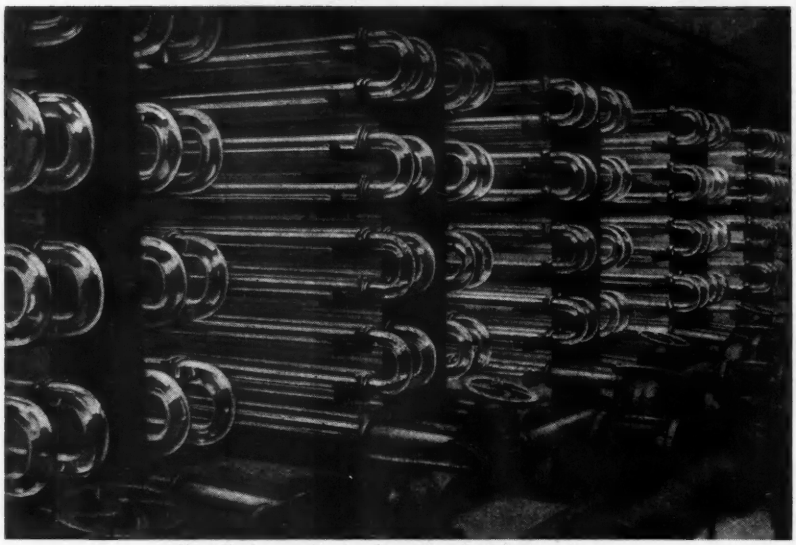

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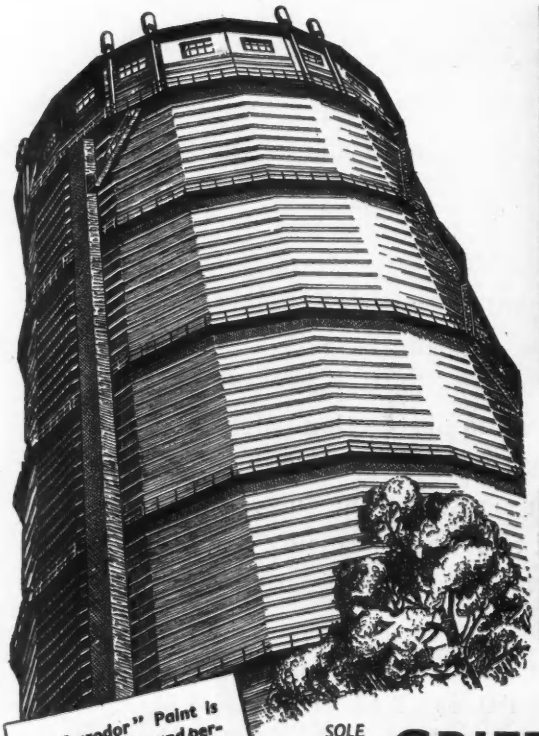

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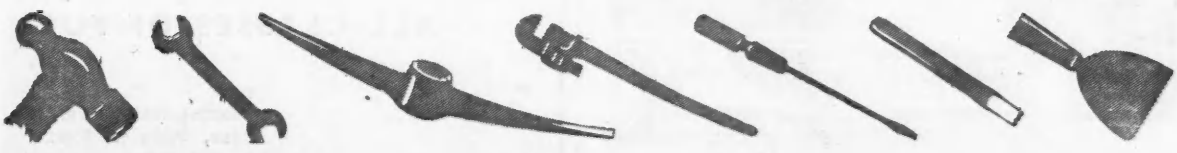

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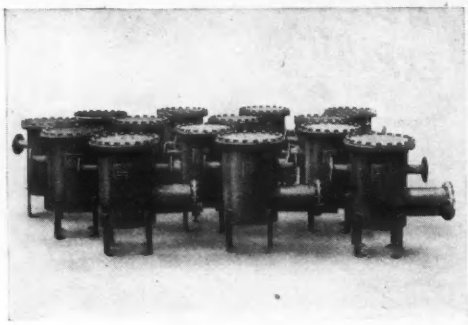

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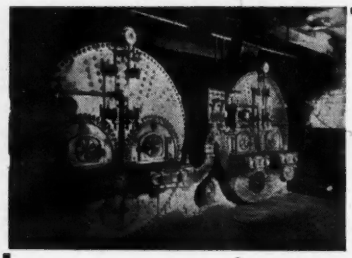

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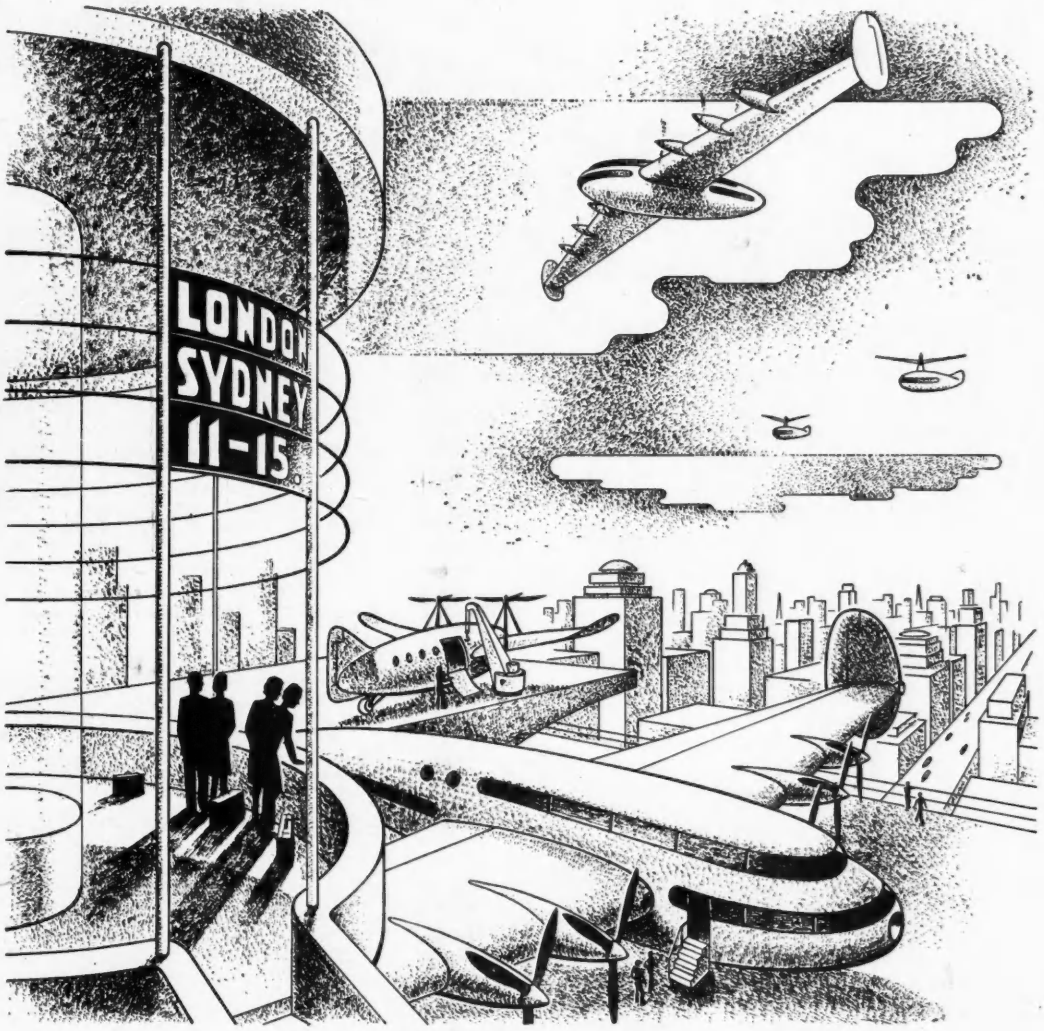

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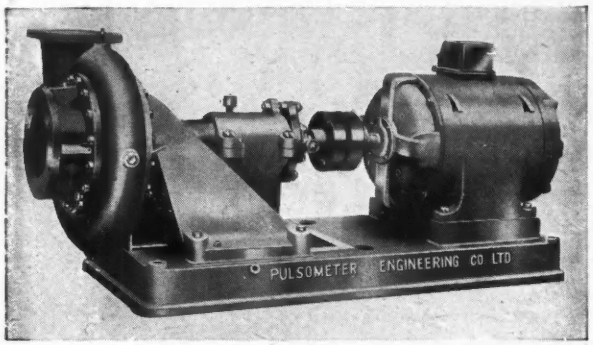

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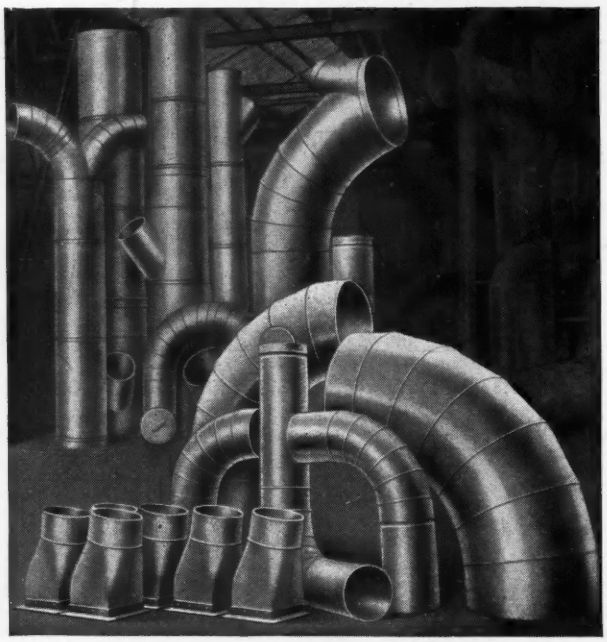

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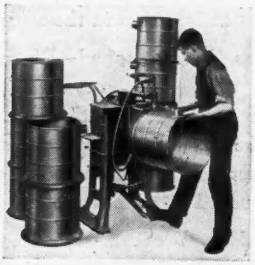

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